Lloyd's Register

Rules and Regulations for the Classification of Naval Ships, January 2006

Notice No. 1

Effective Date of Latest Amendments:

See page 1

Issue date: January 2007

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RULES AND REGULATIONS FOR THE CLASSIFICATION OF NAVAL SHIPS, *January 2006*

Notice No. 1

This Notice contains amendments within the following Sections of the *Rules and Regulations for the Classification of Naval Ships, January 2006.* The amendments are effective on the dates shown:

Volume	***Part***	***Chapter***	***Section***	***Effective date***
1	3	2	6	1 January 2007
1	3	3	3	Corrigendum
1	4	1	5	1 January 2007
1	4	1	2	Corrigendum
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1	4	3	2	1 January 2007
1	4	3	5	Corrigendum
1	5	2	2	Corrigendum
1	5	2	4	1 January 2007
1	5	3	7	1 January 2007
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1	6	2	6	Corrigendum
1	6	3	9, 15	Corrigenda
1	6	6	2	Corrigendum
2	1	1	2, 3	1 January 2007
2	1	2	3, 4, 5	1 January 2007
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2	2	1	1	Corrigendum
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2	2	2	1	Corrigendum
2	2	3	5	1 January 2007
2	2	3	1	Corrigendum
2	3	2	Scope, 1, 2, 3, 4	1 January 2007
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2	5	4	1, 2	1 January 2007
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2	7	3	2, 3, 8	1 January 2007
2	7	3	2, 8	Corrigenda
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2	7	4	2	Corrigendum
2	7	5	3	Corrigendum
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2	9	1	1	Corrigendum
2	10	1	1, 2, 11, 13	1 January 2007
2	10	1	1, 3, 5, 8, 10, 17, 20	Corrigenda
2	11	1	3, 5	Corrigenda
2	11	2	1, 2, 3, 5	Corrigenda
2	11	3	6	Corrigendum
3	1	1	3	1 January 2007
3	1	5	1, 2, 3	1 January 2007
3	1	7	1, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14	1 January 2007
3	1	7	6, 7, 9	Corrigenda

It will be noted that the amendments also include corrigenda, which are effective from the date of this Notice.

The *Rules and Regulations for the Classification of Naval Ships, January 2006* are to be read in conjunction with this Notice No. 1. The status of the Rules is now:

Rules for Naval Ships	Effective date:	January 2006
Notice No. 1	Effective dates:	1 January 2007

Volume 1, Part 3, Chapter 2

Ship Design

Effective date 1 January 2007

■ *Section 6*
Machinery space arrangements

6.1 General

6.1.3 In addition, the requirements of Vol 2, Pt 1, Ch 2,5.1.4 to 5.1.6 are to be complied with.

Volume 1, Part 3, Chapter 3

Ship Control Systems

CORRIGENDUM

■ *Section 3*
Stabiliser arrangements

3.3 Centre of pressure

(*Part only shown*)

Table 3.3.1 Position of centre of pressure

Symbols

x_{PF} = horizontal distance from the centreline of the fin stock, to the centre of pressure in the ahead condition, in metres

x_{PA} = horizontal distance from the centreline of the fin stock, to the centre of pressure in the astern condition, in metres

x_B = breadth of fin, in metres

y_F = depth of fin at centreline of stock, in metres

A_F = fin area, in m^2

x_L and x_A = horizontal distances from leading and after edges, respectively, of the fin to the centreline of the fin stock, in metres

x_S = horizontal length of any rectangular strip of fin geometric form, in metres

~~L_R, B and C_b are as defined in Ch 1,5.2~~
~~V is as defined in 2.11.1~~

Volume 1, Part 4, Chapter 1

Military Design

CORRIGENDUM

■ *Section 2*

Survivability

2.2 Vulnerability

2.2.7 Physical damage may occur to cables, piping, equipment and machinery, and other systems. The duplication or protection of these items is dealt with in Vol 2, Pt 1, ~~Ch 2,4.8~~ Ch 2,4.9. Where protection is required, e.g. armour, the impact on the structural design of the hull is to be considered.

Effective date 1 January 2007

■ *Section 5*

Military design requirements

5.3 Masts and externally mounted sensors or equipment

5.3.3 The effect of ice accretion, *see* Pt 5, Ch 2,4, is to be considered when assessing the strength and support structure of masts. Further consideration is to be given to the increased loading caused by ice accretion on the structure, due to ship motions.

Existing paragraphs 5.3.3 *to* 5.3.8 *have been renumbered* 5.3.4 *to* 5.3.9.

Volume 1, Part 4, Chapter 2

Military Load Specification

CORRIGENDUM

■ *Section 5*

Underwater explosion (shock)

5.3 Notation assessment levels and methodology

5.3.4 For ships where the machinery is in class (**LMC** notation) the requirements of Vol 2, Pt 1, ~~Ch 2,4.10~~ Ch 2,4.11 should also be complied with.

Volume 1, Part 4, Chapter 3

Special Features

Effective date 1 January 2007

■ *Section 2*

Vehicle decks and fixed ramps

CORRIGENDUM

■ *Section 5*

Movable decks, lifts, ~~and~~ internal and external ramps

Volume 1, Part 5, Chapter 2
Environmental Conditions

CORRIGENDUM

■ *Section 2*
Wave environment

2.4 Service Area factors

2.4.5 For restricted Service Area Notation **SAR** the service area factor is to be derived by combining the service areas factors for each sea area using the following formula:

$$f_s = \ln\left(\sum_{i=1}^{n} P_i \, \cancel{e\, f_{si}} \, e^{f_{si}}\right)$$

where

$f_{si} = f_{1i} + f_{2i}\,(L_{WL} - 100)/\,1000$

f_{1i} and f_{2i} are the individual sea area factors given in Table 2.2.3

$e = 2{,}7183$

ln ( ) is the natural log

P_i is defined in 2.5.3.

Effective date 1 January 2007

■ *Section 4*
Guidance for ice environment

4.6 Ice accretion

4.6.1 For ships intended to operate for extended periods in Arctic or Antarctic the build up of ice on exposed surfaces is to be considered. *See* Ch 3,7 and Ch 4,2.

4.6.3 A full icing allowance is defined as an additional pressure of 1 kN/m^2 (100 mm of ice) applied to all exposed horizontal or near horizontal surfaces and 0,25 kN/m^2 (25 mm of ice) applied to all exposed vertical surfaces. The volumetric centre of the ice is to be taken as that of an equivalent head of water. The density of the ice is assumed to be 1000 kg/m^3.

~~*4.6.3*~~ *4.6.4* As a minimum a half icing allowance is to be applied to vessels operating in the winter seasonal areas as defined in the ~~international convention for load lines~~ International Load Line Convention.

4.6.5 A half icing allowance is defined as an additional pressure of 0,5 kN/m^2 (50 mm of ice) applied to all exposed horizontal or near horizontal surfaces and 0,18 kN/m^2 (18 mm of ice) applied to all exposed vertical surfaces. The volumetric centre of the ice is to be taken as that of an equivalent head of water. The density of the ice is assumed to be 1000 kg/m^3.

~~*4.6.4* The icing allowance it to be applied to the still water bending moment calculation in accordance with Pt 5, Ch 4,2 and in the local loading section for the appropriate areas in accordance with Pt 5, Ch 3,7.~~

~~*4.6.5*~~ *4.6.6* The effects on stability of ice accretion are to be assessed in accordance with the stability standard identified by the Naval Authority.

4.6.7 Where alternative icing allowances are specified by the Naval Authority and these allowances exceed that defined in 4.6.3 and 4.6.5 for the appropriate operational areas, these allowances shall be used in the assessment of the local and global structure.

Volume 1, Part 5, Chapter 3
Local Design Loads

Effective date 1 January 2007

■ *Section 7*
Ice loads

7.1 General

7.1.1 ~~A half or full icing allowance is to be included in the local load calculation of ships that are required to operate for extended periods in areas where ice accretion is expected, *see* Pt 5,Ch 2,4.~~ A half or full icing allowance in accordance with Pt 5, Ch 2,4 is to be included in the local load calculations of plating and stiffed panels of ships that are required to operate for extended periods in areas where ice accretion is expected.

~~7.2 Ice loads for full icing allowance~~

~~*7.2.1* For local strength calculations of plating and stiffened panels a pressure additional to that normally required of 1 kN/m^2 (100 mm of ice) is to be applied to all exposed horizontal or near horizontal surfaces.~~

~~*7.2.2* For local strength calculations of plating and stiffened panels a pressure additional to that normally required of 0,25 kN/m^2 (25 mm of ice) is to be applied to all exposed vertical surfaces.~~

~~7.3 Ice loads for half icing allowance~~

~~*7.3.1* For local strength calculations of plating and stiffened panels a pressure additional to that normally required of 0,5 kN/m^2 (50 mm of ice) is to be applied to all exposed horizontal or near horizontal surfaces.~~

~~*7.3.2* For local strength calculations of plating and stiffened panels a pressure additional to that normally required of 0,18 kN/m^2 (18 mm of ice) is to be applied to all exposed vertical surfaces.~~

Volume 1, Part 5, Chapter 4
Global Design Loads

Effective date 1 January 2007

■ *Section 2*
Still water global loads

2.1 General

2.1.6 ~~For ships that are designed to operate for extended periods in areas where ice accretion is expected, *see* Pt 5, Ch 2,4, a full or half icing allowance may need to be included in the still water bending moment and shear force calculation.~~ A full or half icing allowance in accordance with Pt 5, Ch 2,4 is to be included in the still water bending moment and shear force calculations.

~~*2.1.7* A full icing allowance is defined as a thickness of 100 mm of ice (1 kN/m^2) applied to all exposed horizontal or near horizontal surfaces. A thickness of 25 mm of ice (0,25 kN/m^2) applied to all exposed vertical surfaces. The centre of gravity of the ice is to be taken as that of an equivalent head of water. The density of ice is assumed to be 1000 kg/m^3.~~

~~*2.1.8* A half icing allowance is the same as that applied for a full icing allowance but with a thickness of 50 mm (0,5 kN/m^2) for horizontal and 18 mm (0,18 KN/m^2) for vertical surfaces.~~

~~*2.1.9*~~ *2.1.7* To account for miscellaneous fittings such as stanchions and rails an additional 5 per cent should be added to the total ice weight calculated for both full and half icing allowances.

Volume 1, Part 6, Chapter 2

Design Tools

CORRIGENDUM

■ *Section 6*
Dynamic loading

6.2 Gradually applied load

(*Part only shown*)

Table 2.6.1 Tabulated dynamic load factors

	Dynamic load factor			Time to maximum displacement		
t_1/T	Gradual f_{DLF}	Triangular f_{DLF}	Instant f_{DLF}	Gradual t_m/t_1	Triangular $t_m/2t_1$	Instant t_m/T
5,9	1,017	1,017	1,876		0,505	0,490
≥6,0	1,002	1,002	1,870		0,500	0,491

Volume 1, Part 6, Chapter 3

Scantling Determination

CORRIGENDA

■ *Section 9*
Bulkheads and deep tanks

9.6 Wash plates

9.6.3 The general stiffener requirements are to be in accordance with ~~3.12~~ 3.11 for NS1 ships and 4.6 for NS2 and NS3 ships. However, the section modulus may be 50 per cent of that required if the end connections are bracketed.

■ *Section 15*
Strengthening for wave impact loads above waterline

15.2 Strengthening against bow flare wave impacts

(*Part only shown*)

15.2.4 The scantlings of secondary stiffeners are not to be less than:

(b) Web area of secondary stiffeners

$$A = 3{,}7 s_{cm}\, \cancel{k}\, k_s\, h_s \left(l_e - \frac{s_{cm}}{2000} \right) \times 10^{-4} \quad \text{cm}^2$$

(*Part only shown*)

15.2.5 The scantlings of primary members are not to be less than:

(a) Section modulus of primary members

$Z = 2\gamma_Z\, \cancel{k}\, k_s\, h_s\, q\, \nu\, l_e^2 \quad \text{cm}^3$

(b) Web area of primary members

$A = 0{,}2\gamma_A\, \cancel{k}\, k_s\, h_s\, q\, \nu\, l_e \quad \text{cm}^2$

Volume 1, Part 6, Chapter 6

Material and Welding Requirements

CORRIGENDUM

■ *Section 2*
Materials

2.4 Ships operating in cold weather conditions

2.4.1 Unless otherwise specified, all ships designed for sea area SA1 and other ships intended to operate for extended periods in cold weather conditions, the minimum toughness requirements for the material of the hull structure are specified in Fig. 6.2.2 and Table 6.2.5. The requirements are based on a design air temperature of –30°C. Where an alternative design air temperature is required, the materials selected are to be in accordance with Pt 3, Ch 2,3 of the *Rules and Regulations for the Classification of Ships* (hereinafter referred to as the Rules for Ships). In the absence of specific information, the air temperature should be taken as:

- for Ice class 1C first year strengthened ships not higher than –30°C,
- for Ice class 1AS, 1A and 1B first year ice strengthened ships not higher than –40°
- for multi year ice strengthened ice breaking ships not higher than –50°.

In all cases the water temperature should not be taken higher than –10°C.

Volume 2, Part 1, Chapter 1

General Requirements for Classification of Engineering Systems

Effective date 1 January 2007

■ *Section 2*
Engineering systems classification provisions

2.1 Provisions

2.1.1 The classification provisions for engineering systems installed in naval ships address the following:

(a) The suitability and functioning of equipment and systems for maintaining the watertight and weathertight integrity of the hull, and spaces within the hull.
(b) The safety and reliability of propulsion, steering and other essential engineering systems.
(c) The operation and functioning of systems installed for operational requirements relating to the ship type and additional Class notations excluding the operation and functioning of military systems.
(d) The effectiveness of systems which have been built into the ship in order to maintain basic conditions on board whereby appropriate stores, fuels, equipment and personnel can be safely carried whilst the ship is at sea, at anchor, or moored in harbour.

■ *Section 3*
Engineering system designation

3.1 Categories

3.1.3 Ship Type category engineering systems are those systems installed in order for the ship to carry out its in-service purpose and are necessary for:

(a) The operation and functioning of systems and equipment installed for purposes relating to the ship type excluding the operation and functioning of military systems.
(b) The operation and functioning of emergency machinery and equipment.

Volume 2, Part 1, Chapter 2

Requirements for Design, Construction, Installation and Sea Trials of Engineering Systems

CORRIGENDA

■ *Section 3*
Particulars to be submitted

3.3 Calculations and specifications

3.3.10 **NBC Protection arrangements**. Where the Naval Authority has defined NBC Protection requirements, a design statement together with plans and particulars are to be submitted for information. *See* ~~4.11~~ 4.12 for NBC Protection guidance.

3.3.11 **Shock resistance arrangements**. Where the Naval Authority has defined shock capability requirements for machinery, engineering systems and equipment, a design statement together with plans and particulars are to be submitted for information. *See* ~~4.10~~ 4.11 for shock resistance guidance.

3.3.12 **Underwater signature arrangements**. Where the Naval Authority has defined underwater signature requirements for the ship and propulsion system, a design statement together with plans and particulars are to be submitted for information. *See* ~~4.9~~ 4.10 for underwater signature guidance.

3.3.13 **Electromagnetic compatibility.** A test plan in accordance with Clause 5 of IEC 60533 for electromagnetic compatibility is to be submitted for information. *See* ~~4.12~~ 4.13 for EMC requirements.

Effective date 1 January 2007

3.3.17 **Machinery operation**. For mobility and ship type category engineering systems, the equipment/machinery manufacturer's instructions for installation and operation of lubricating and hydraulic oil systems are to be made available to the LR surveyors attending trials/testing/commissioning. The instructions should include information that may affect the safety and reliability of the equipment covering requirements for operating environment, monitoring arrangements, cleanliness, filter arrangements, oil change intervals and precautions to be taken at start-up, in operation and during prolonged periods of shut-down.

■ *Section 4*
Operating conditions

4.1 Availability for operation

4.1.4 Installed machinery is to be capable of operating and being maintained in accordance with the manufacturer's instructions as required by 3.3.7 and 3.3.17.

4.5 Ambient operating conditions

4.5.1 Main and essential auxiliary machinery and equipment is to be capable of operating satisfactorily under the conditions shown in Table 2.4.1.

4.5.2 Where it is intended to allow for operation in ambient temperatures outside those shown in Table 2.4.1, the permissible temperatures and associated periods of time are to be specified by the manufacturer and agreed by the Owner/Operator. Engineering systems should retain a continuous level of functional capability under these conditions and any level of degraded performance should be defined. Operation under these circumstances should not be the cause of damage to equipment in the system.

~~4.5~~ 4.6 Inclination of ship

Existing paragraphs 4.5.1 *to* 4.5.4 *have been renumbered* 4.6.1 *to* 4.6.4.

Existing Table 2.4.1 *has been renumbered* Table 2.4.2.

~~4.5.1~~ 4.6.1 Main and essential auxiliary machinery, electrical and emergency equipment is to operate satisfactorily under the conditions as shown in ~~Table 2.4.1~~ Table 2.4.2.

~~4.5.2~~ 4.6.2 The arrangements for lubricating bearings and for draining crankcase and oil sumps of main and auxiliary engines, gearcases, electric generators, motors and other running machinery are to be designed so that they will remain efficient with the ship inclined under the conditions shown in ~~Table 2.4.1~~ Table 2.4.2.

~~4.5.3~~ 4.6.3 Any proposal to deviate from the angles given in ~~Table 2.4.1~~ Table 2.4.2 will be specially considered taking into account the type, size and service conditions of the ship.

~~4.5.4~~ 4.6.4 The dynamic angles of inclination in ~~Table 2.4.1~~ Table 2.4.2 may be exceeded in certain circumstances dependent upon ship type and operation. The Shipbuilder is, therefore, to ensure that the machinery is capable of operating under these angles of inclination.

~~4.6~~ 4.7 Power conditions for generator sets

Existing paragraphs 4.6.1 *and* 4.6.2 *have been renumbered* 4.7.1 *and* 4.7.2.

~~4.6.2~~ 4.7.2 Engine builders are to satisfy the Surveyors by tests on individual engines that the requirements in ~~4.6.1~~ 4.7.1, as applicable, can be complied with, due account being taken of the difference between the temperatures under test conditions and those referred to in 4.4.1. Alternatively, where it is not practicable to test the engine/generator set as a unit, type tests (e.g. against a brake) representing a particular size and range of engines may be accepted. With oil engines and gas turbines any fuel stop fitted is to be set to permit the short period overload power of not less than 10 per cent above full rated output (kW) being developed.

~~4.7~~ 4.8 Astern power

Existing paragraphs 4.7.1 *and* 4.7.2 *have been renumbered* 4.8.1 *and* 4.8.2.

Table 2.4.1 Ambient operating conditions

Air		
Installations, components	Location, arrangement	Temperature range (ºC)
Machinery and electrical installations	In enclosed spaces	0 to +45, *see* Note 1
	On machinery components, boilers, In spaces subject to higher and lower temperatures	According to specific local conditions, *see* Note 2
	On the open deck	–25 to +45, *see* Note 1
Water		
Coolant		Temperature (ºC)
Sea-water or charge air coolant inlet to charge air cooler		–2 to +32, *see* Note 1

NOTES
1. For ships intended to be classed for restricted service, a deviation from the temperatures stated may be considered.
2. Details of local environmental conditions are stated in Annex B of IEC 60092: *Electrical installations in ships – Part 101: Definitions and general requirements*.

~~4.8~~ 4.9 Military requirements

Existing paragraphs 4.8.1 *to* 4.8.6 *have been renumbered* 4.9.1 *to* 4.9.6.

~~4.9~~ 4.10 Guidance for underwater signature

Existing paragraphs 4.9.1 *to* 4.9.4 *have been renumbered* 4.10.1 *to* 4.10.4.

Existing Table 2.4.2 *has been renumbered* Table 2.4.3.

~~4.9.1~~ 4.10.1 Where military requirements for under-water signature have been identified by the Naval Authority, the guidance in ~~4.9.2 to 4.9.4~~ 4.10.2 to 4.10.4 may be used to assist in achieving the requirements. The Naval Authority is responsible for defining the underwater signature and any requirements in addition to the guidance in this Section. The design statement is to include underwater signature levels for the ship and propulsion system, which should be agreed between the Designer and Owner/Operator, *see* 3.3.12.

~~4.9.3~~ 4.10.3 The techniques that may be employed for control of underwater signature are outlined in ~~Table 2.4.2~~ Table 2.4.3 for guidance purposes.

~~4.10~~ 4.11 Guidance for shock resistance

Existing paragraphs 4.10.1 *to* 4.10.27 *have been renumbered* 4.11.1 *to* 4.11.27.

~~4.10.1~~ 4.11.1 Where military requirements for machinery, engineering systems and equipment to have shock resistance have been identified by the Naval Authority, the guidance in ~~4.10.2 to 4.10.27~~ 4.11.2 to 4.11.27 may be used to assist in achieving the requirements. The Naval Authority is responsible for defining the levels of shock resistance and any requirements in addition to the guidance in this Section. The design statement is to include shock capability levels for installed machinery, engineering systems and equipment which should be agreed between the Designer and Owner/Operator, *see* 3.3.11.

(*Part only shown*)
~~4.10.2~~ 4.11.2 Design of shock resistance for installed machinery, engineering systems and equipment should address:

The application of design and installation of machinery systems for shock resistance is dependent on the Owner/Operator requirements as shock capability may range from either full operational capability after repeated shock to that for retaining items captive to avoid injury to personnel. *See* ~~4.10.1~~ 4.11.1 for design statement requirements.

~~4.10.4~~ 4.11.4 Where military requirements to reduce the risks of shock damage to machinery, engineering systems and equipment have been identified by the Naval Authority, the good design practice guidance in ~~4.10.5 to 4.10.27~~ 4.11.5 to 4.11.27 may be used to assist in achieving the requirements. The use of the guidance will not guarantee that an item of equipment will remain undamaged following shock but will provide confidence that most of the common design deficiencies are identified and avoided.

~~4.11~~ 4.12 Guidance for NBC protection, detection and monitoring

Existing paragraphs 4.11.1 *to* 4.11.14 *have been renumbered* 4.121.1 *to* 4.12.14.

~~4.11.1~~ 4.12.1 Where military requirements to operate under the threat of Nuclear, Biological and Chemical (NBC) warfare have been identified by the Naval Authority, the guidance in ~~4.11.2 to 4.11.14~~ 4.12.2 to 4.12.14 may be used to assist in achieving the requirements. The Naval Authority is responsible for defining the levels of threat, operating periods and for specifying any NBC Protection requirements in addition to the guidance in this Section. The design statement for NBC Protection of the ship should be agreed between the Designer and Owner/Operator, *see* 3.3.10. For hull structure guidance, *see* Vol 1, Pt 4, Ch 1,7.

~~4.12~~ 4.13 Electromagnetic compatibility (EMC)

Existing paragraphs 4.12.1 *to* 4.12.3 *have been renumbered* 4.13.1 *to* 4.13.3.

~~4.13~~ 4.14 Machinery interlocks

Existing paragraphs 4.13.1 *has been renumbered* 4.14.1.

~~4.14~~ 4.15 Stopping of machinery

Existing paragraphs 4.14.1 *and* 4.14.2 *have been renumbered* 4.15.1 *and* 4.15.2.

~~4.15~~ 4.16 Failure of control operating medium

Existing paragraphs 4.15.1 *to* 4.15.4 *have been renumbered* 4.16.1 *to* 4.16.4.

~~4.15.1~~ 4.16.1 Diesel engines and gas turbines are to be capable of operation at the maximum continuous power after loss or reduction of the normal control system operating medium, e.g. hydraulic, pneumatic or electrical, in accordance with the requirements in ~~4.15.2 to 4.15.4~~ 4.16.2 to 4.16.4.

~~4.15.4~~ 4.16.4 Emergency hand control is to be provided where necessary to enable the requirements for safe operation called for by ~~4.15.2~~ 4.16.2 to be assured following auto and/or remote control system failure.

~~4.16~~ 4.17 Control of rotating systems

Existing paragraphs 4.16.1 *to* 4.16.3 *have been renumbered* 4.17.1 *to* 4.17.3.

~~4.16.3~~ 4.17.3 The arrangements for control of rotating systems are to comply with Pt 9, Ch 1 as applicable and are to be such that failure in any item of equipment in the control system does not cause a hazard to the operation of the prime mover. The arrangements are to comply with the requirements of ~~4.15~~ 4.16 as applicable.

~~4.17~~ 4.18 Survey and refit

Existing paragraph 4.17.1 *has been renumbered* 4.18.1.

~~4.18~~ 4.19 Electromagnetic hazards

Existing paragraphs 4.18.1 *to* 4.18.2 *have been renumbered* 4.19.1 *to* 4.19.2.

~~4.19~~ 4.20 Flexible hose and bellows expansion piece registers

Existing paragraphs 4.19.1 *to* 4.19.4 *have been renumbered* 4.20.1 *to* 4.20.4.

Existing Table 2.4.3 *has been renumbered* Table 2.4.4.

(*Part only shown*)
~~4.19.2~~ 4.20.2 The following information is to be included in the Register:

A typical Flexible Hose Register format is shown in ~~Table 2.4.3~~ Table 2.4.4.

~~4.19.4~~ 4.20.4 A Naval Authority may require the scope of a flexible hose or expansion bellows piece Register for purposes other than those detailed in ~~4.19.1~~ 4.20.1.

■ *Section 5*
Machinery space arrangements

5.1 Machinery spaces

5.1.7 In addition, the requirements of Vol 1, Pt 3, Ch 2,6 are to be complied with.

5.4 Resilient mountings

5.4.1 The dynamic angles of inclination in ~~Table 2.4.1~~ Table 2.4.2 may be exceeded in certain circumstances dependent upon ship type and operation. The Shipbuilder is, therefore, to ensure that the vibration levels of flexible pipe connections, shaft couplings and mounts remain within the limits specified by the component manufacturer for the conditions of maximum dynamic inclinations to be expected during service, start-stop operation and the natural frequencies of the system. Due account is to be taken of any creep that may be inherent in the mount.

Volume 2, Part 2, Chapter 1
Diesel Engines

CORRIGENDUM

■ *Section 1*
General requirements

1.4 Inclination of ship

1.4.1 Main and essential auxiliary diesel engines are to operate satisfactorily under the conditions as shown in ~~Table 2.4.1~~ Table 2.4.2 in Pt 1, Ch 2.

Effective date 1 January 2007

■ *Section 4*
Crankshaft design

4.1 Application and information to be submitted

4.1.5 In addition to detailed dimensioned plans, the following information is required to be submitted:

- Engine type – 4SCSA/2SCSA/in-line/vee.
- Output power at maximum continuous rating (MCR), in kW.
- Output speed at maximum continuous power, in rpm.
- Maximum cylinder pressure, in bar g.
- Mean indicated pressure, in bar g.
- Cylinder air inlet pressure, in bar g.
- Digitized gas pressure/crank angle cycle for MCR.
- Maximum pressure/speed relationship.
- Compression ratio.
- Vee angle and firing interval (if applicable), in degrees.
- Firing order numbered from driving end.
- Cylinder diameter, in mm.
- Piston stroke, in mm.
- Mass of connecting rod (including bearings), in kg.
- Centre of gravity of connecting rod from large end centre, in mm.
- Radius of gyration of connecting rod, in mm.
- Length of connecting rod between bearing centres, in mm.
- Mass of single crankweb (indicate if webs either side of pin are of different mass values), in kg.
- Centre of gravity of crankweb mass from shaft axis, in mm.
- Mass of counterweights fitted (for complete crankshaft) indicate positions fitted, in kg.
- Centre of gravity of counterweights (for complete crankshaft) measured from shaft axis, in mm.
- Mass of piston (including piston rod and crosshead where applicable), in kg.
- All individual reciprocating masses acting on one crank, in kg.

- Material specification(s).
- Specified minimum UTS, in N/mm^2.
- Specified minimum yield strength, in N/mm^2.
- Method of manufacture.
- Details of fatigue enhancement process (if applicable).
- For semi-built crankshafts – minimum and maximum diametral interference, in mm.

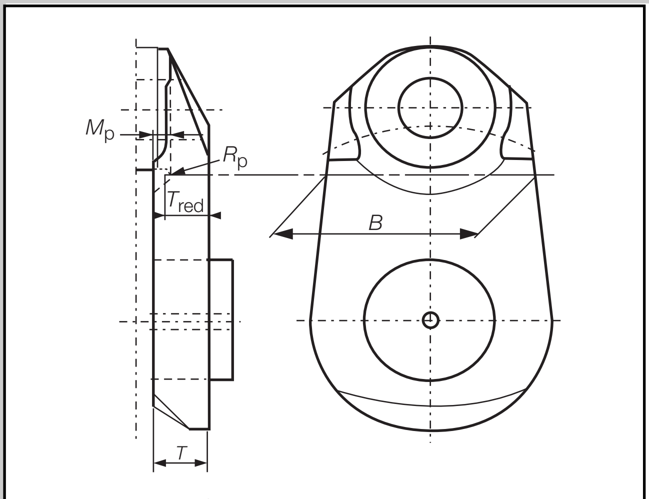
4.2 Symbols

4.2.1 For the purposes of this Chapter the following symbols apply (*see also* Fig. 1.4.1):

h = radial thickness of web, in mm
k_e = bending stress factor
B = transverse breadth of web, in mm
D_p, D_j = outside diameter of pin or main journal, in mm
D_{pi}, D_{ji} = internal diameter of pin or main journal, in mm
D_s = shrink diameter of main journal in web, in mm
d_o = diameter of radial oil bore in crankpin, in mm
F = alternating force at the web centreline, in N
K_1 = fatigue enhancement factor due to manufacturing process
K_2 = fatigue enhancement factor due to surface treatment
M_b = alternating bending moment at web centreline, in N-mm (Note: alternating is taken to be $^1/_2$ range value)
M_{BON} = alternating bending moment calculated at the outlet of crankpin oil bore
M_p, M_j = undercut of fillet radius into web measured from web face, in mm
R_p, R_j = fillet radius at junction of web and pin or journal, in mm
S = stroke, in mm
T = axial thickness of web, in mm
T_a = alternating torsional moment at crankpin or crank journal, in N-mm (Note: alternating is taken to be $^1/_2$ range value)
U = pin overlap

$$\frac{(D_p + D_j - S)}{2} \text{ mm}$$

α_B = bending stress concentration factor for crankpin
α_T = torsional stress concentration factor for crankpin
β_B = bending stress concentration factor for main journal
β_Q = direct shear stress concentration factor for main journal
β_T = torsional stress concentration factor for main journal
γ_B = bending stress concentration factor for radially drilled oil hole in the crankpin
γ_T = torsional stress concentration factor for radially drilled oil hole in the crankpin
σ_{ax} = alternating axial stress, in N/mm^2
σ_b = alternating bending stress, in N/mm^2
σ_{BON} = alternating bending stress in the outlet of the oil bore, in N/mm^2
σ_p,σ_j = maximum bending stress in pin and main journal taking into account stress raisers, in N/mm^2
σ_{BO} = maximum bending stress in the outlet of the oil bore, in N/mm^2
σ_u = specified minimum UTS of material, in N/mm^2
σ_y = specified minimum yield stress of material, in N/mm^2
σ_Q = alternating direct stress, in N/mm^2
τ_a = alternating torsional stress, in N/mm^2



Crankshaft without overlap

Fig. 1.4.2
Crank dimensions for crankshaft without overlap

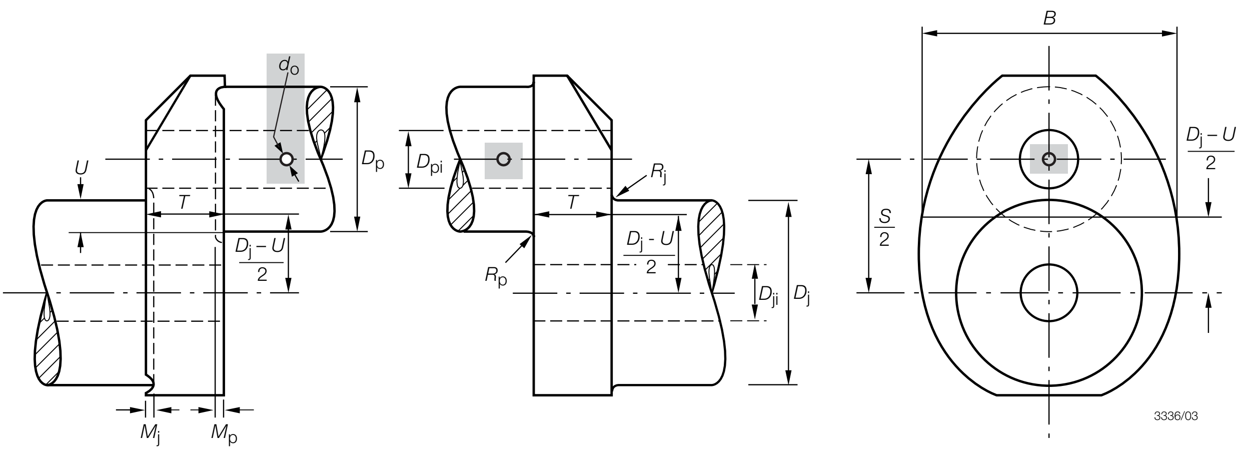


Fig. 1.4.1 Crank dimensions necessary for the calculation of stress concentration factors

τ_p, τ_j = maximum torsional stress in pin and main journals taking into account stress raisers, in N/mm^2

τ_{ob} = maximum torsional stress in outlet of crankpin oil bore taking into account stress raisers, in N/mm^2.

4.3 Stress concentration factors

(*Part only shown*)

4.3.3 Crank journal stress concentration factors (not applicable to semi-built crankshafts):

4.3.4 Crankpin oil bore stress concentration factors for radially drilled oil holes:

- Bending

$\gamma_B = 3 - 5{,}88 \bullet d_o + 34{,}6 \bullet d_o^2$

- Torsion

$\gamma_T = 4 - 68 \bullet d_o + 30 \bullet d_o^2$

~~*4.3.4*~~ *4.3.5* Where experimental measurements of the stress concentrations are available, these may be used. The full documented analysis of the experimental measurements is to be submitted for consideration.

4.3.6 In the case of semi-built crankshafts when $M_p > R_p$ the web thickness is to be taken as

$T_{red} = T - (M_p - R_p)$ and the web width B is to be taken in way of the crankpin fillet radius centre *see* Fig. 1.4.2.

Table 1.4.1 Crankshaft variables

Variable	Range	
	Lower	Upper
$b = B/D_p$	~~1,20~~ 1,10	2,20
$d_j = D_{ji}/D_p$	0,00	0,80
$d_p = D_{pi}/D_p$	0,00	0,80
$m_j = M_j/D_p$	0,00	r_{jb}
$m_p = M_p/D_p$	0,00	r_p
$r_{jB} = R_j/D_p$	0,03	0,13
$r_{jT} = R_j/D_j$	0,03	0,13
$r_p = R_p/D_p$	0,03	0,13
$t = T/D_p$	0,20	0,80
$t = T_{red}/D_p$ *see* Note 3	0,20	0,80
$d = d_o/D_p$	0,00	0,20
$u = U/D_p$	–0,50	~~0,70~~ 0,50

NOTES

1. Where variables fall outside the range, alternative methods are to be used and full details submitted for consideration.
2. ~~A lower limit *u* down to –0,7 is acceptable, but for calculation purposes the limit in the above Table applies.~~
2. A lower limit of *u* can be extended down to large negative values provided that:
   (i) If calculated *f(rec)* < 1 then the factor *f(rec)* is not to be considered (*f(rec)* = 1)
   (ii) If *u* < –0.5 then *f(ut)* and *f(ru)* are to be evaluated replacing actual value of *u* by –0,5.
3. For crankshafts without overlap *see also* 4.3.6.

4.4 Nominal stresses

4.4.4 Nominal alternating bending stress, σ_{BON}, in the outlet of the crankpin oil bore, in N/mm^2:

$$\sigma_{BON} = \pm \frac{M_{BON}}{Z_{crankpin}}$$

where

M_{BON} is taken as the $^1/_2$ range value

$M_{BON} = \pm ^1/_2 \, (M_{BOmax} - M_{BOmin})$

and

$M_{BO} = (M_{BTO} \cos \psi + M_{BRO} \sin \psi)$ *see* Fig. 1.4.3

The two relevant bending moments are taken in the crankpin cross-section through the oil bore.

M_{BRO} = bending moment of the radial component of the connecting-rod force

M_{BTO} = bending moment of the tangential component of the connecting-rod force

$$Z_{crankpin} = \frac{\pi}{32}\left[\frac{D^4 - d^4}{d}\right]$$ with $Z_{crankpin}$ related to the cross-section of axially bored crankpin.

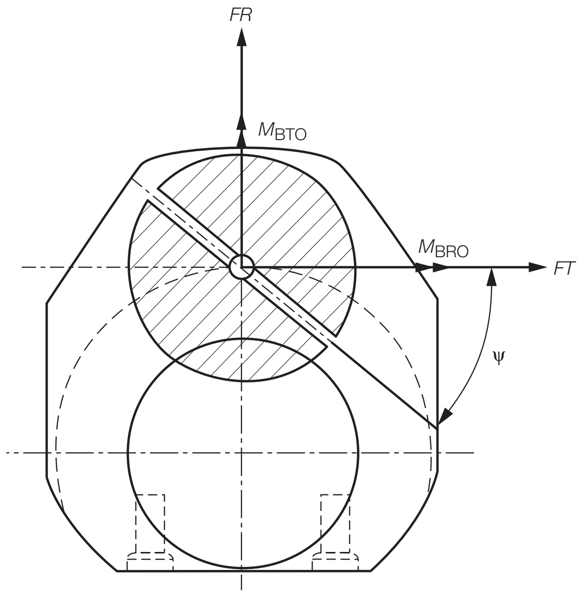


Fig. 1.4.3 Crankpin section through the oil bore

~~*4.4.4*~~ *4.4.5* The nominal direct shear stress in the web for the purpose of assessing the main journal is to be added algebraically to the bending stress, using the alternating forces which have been used in deriving M_b in 4.4.3.

~~*4.4.5*~~ *4.4.6* Nominal stress is referred to the web cross-section area or the pin cross-section area as applicable.

Existing paragraphs 4.4.6, 4.4.7 *and* 4.4.8 *have been renumbered* 4.4.7, 4.4.8 *and* 4.4.9.

~~4.4.9~~ *4.4.10* Nominal alternating torsional stress:

$$\tau_a = \pm \frac{T_a}{Z_T} \text{ N/mm}^2$$

where

Z_T = torsional modulus of crankpin and main journal

~~= $\pi \frac{(D^4 - d^4)}{16D}$ mm^3~~

= $\frac{\pi}{16}\left(\frac{D^4 - d^4}{16D}\right)$ mm^3

D = outside diameter of crankpin or main journal, in mm

d = inside diameter of crankpin or main journal, in mm

τ_a is to be ascertained from assessment of the torsional vibration calculations where the maximum and minimum torques are determined for every mass point of the complete dynamic system and for the entire speed range by means of a harmonic synthesis of the forced vibrations from the 1st order up to and including the 15th order for 2-stroke cycle engines and from the 0,5th order up to and including the 12th order for 4-stroke cycle engines. Whilst doing so, allowance must be made for the damping that exists in the system and for unfavourable conditions (misfiring in one of the cylinders when no combustion occurs but only compression cycle). The speed step calculation shall be selected in such a way that any resonance found in the operational speed range of the engine shall be detected.

If T_a is not known, a value can be calculated by the following formula as an approximation in the first instance:

$$T_a = \left((18{,}6 - 0{,}0132 D_e) \times \frac{\sigma_u + 160}{560}\right) \times Z_e$$ ~~N/mm~~ Nmm

where

$$D_e = D_j \sqrt[3]{1 + \left(\frac{D_{ji}}{D_j}\right)^4}$$

or

$$D_e = D_p \sqrt[3]{1 - \left(\frac{D_{pi}}{D_p}\right)^4}$$

whichever is the smaller

Z_e = corresponding torsional modulus

= $\pi \dfrac{(D_e{}^4 - d^4)}{16 D_e}$ mm^3

4.4.11 For the purpose of the crankshaft assessment, the nominal alternating torsional stress considered in calculations is to be the highest calculated value, according to the method described in 4.4.9, occurring at the most torsionally loaded mass point of the crankshaft system.

4.4.12 The approval of the crankshaft will be based on the installation having the largest nominal alternating torsional stress (but not exceeding the maximum figure specified by the engine manufacturer). For each installation it is to be ensured by calculation that the maximum approved nominal alternating torsional stress is not exceeded.

Existing paragraphs 4.4.10 *and* 4.4.11 *have been renumbered* 4.4.13 *and* 4.4.14.

4.5 Maximum stress levels

4.5.2 Outlet of crankpin oil bore:

- Maximum alternating bending stress:

$$\sigma_{BO} = \gamma_B (\sigma_{BON} + \sigma_{ax}) \text{ N/mm}^2$$

where

γ_B = bending stress concentration factor, *see* 4.3.4

- Maximum alternating torsional stress:

$$\tau_{tob} = \gamma_T \tau_a \text{ N/mm}^2$$

where

γ_T = torsional stress concentration factor, *see* 4.3.4

τ_a = nominal alternating torsional stress in crankpin N/mm^2.

~~4.5.2~~ *4.5.3* Crank journal fillet (not applicable to semi-built crankshafts).

Maximum alternating bending stress:

$$\sigma_j = \beta_B (\sigma_b + \sigma_{ax}) + \beta_Q \sigma_Q \text{ N/mm}^2$$

where

β_B = bending stress concentration (*see* 4.3.3)

β_Q = direct stress concentration (*see* 4.3.3)

Maximum alternating torsional stress:

$$\tau_j = \beta_T \tau_a \text{ N/mm}^2$$

where

β_T = torsional stress concentration (*see* 4.3.3)

τ_a = nominal alternating torsional stress in main journal N/mm^2

4.6 Equivalent alternating stress

4.6.2 Equivalent alternating stress for the outlet of the crankpin oil bore σ_{eob}, is defined as:

$$\sigma_{eob} = \pm \frac{1}{3} \sigma_{bo} \left[1 + 2\sqrt{1 + \frac{9}{4}\left(\frac{\tau_{to}}{\sigma_{bo}}\right)^2}\,\right] \text{ N/mm}^2$$

4.7 Fatigue strength

4.7.1 The fatigue strength of a crankshaft is based upon the crankpin and crank journal as follows:

$$\sigma_{fp} = K_1 K_2 (0{,}42\sigma_u + 39{,}3)\left(0{,}264 + 1{,}073 D_p^{-0{,}2} + \frac{785 - \sigma_u}{4900} + \frac{196}{\sigma_u}\sqrt{\frac{1}{R_p}}\right) \text{N/mm}^2$$

To calculate the fatigue strength in the oil bore area, replace R_p with ½d_o and σ_{fp} with σ_{fob}

$$\sigma_{fj} = K_1 K_2 (0{,}42\sigma_u + 39{,}3)\left(0{,}264 + 1{,}073 D_j^{-0{,}2} + \frac{785 - \sigma_u}{4900} + \frac{196}{\sigma_u}\sqrt{\frac{1}{R_j}}\right) \text{N/mm}^2$$

where

σ_u = UTS of crankpin or crank journal as appropriate, in N/mm^2

K_1 = fatigue endurance factor appropriate to the manufacturing process

= 1,05 for continuous grain-flow (CGF) or die-forged

= 1,0 for freedom forged (without CGF)

= 0,93 for cast steel manufactured using a LR approved cold rolling process

K_2 = fatigue enhancement factor for surface treatment These treatments are to be applied to the fillet radii.

4.7.2 A value for K_2 will be assigned upon application by the engine designers. Full details of the process, together with the results of full scale fatigue tests will be required to be submitted for consideration. Alternatively, the following values may be taken (surface hardened zone to include fillet radii):

K_2 = 1,15 for induction hardened
= 1,25 for nitrided

Where a value of K_1 or K_2 greater than unity is to be applied then details of the manufacturing process are to be submitted.

4.8 Acceptability criteria

4.8.1 The acceptability factor, Q, is to be greater than 1,15:

$Q = \dfrac{\sigma_f}{\sigma_e}$ for crankpin, ~~and~~ journal and the outlet of crankpin oil bore

where

$\sigma_f = \sigma_{fp}$ or σ_{fj} or σ_{ob}
$\sigma_e = \sigma_{ep}$ or σ_{ej} or σ_{eob}

4.9 Crankshaft oil hole

4.9.1 The junction of the oil hole with the crankpin or main journal surface is to be formed with an adequate radius and smooth surface finish down to a minimum depth equal to 1,5 times the oil bore diameter.

4.9.3 When journal diameter is equal or larger than the crankpin diameter, the outlets of main journal oil bores are to be formed in a similar way to the crankpin oil bores, otherwise separate fatigue strength calculations or, alternatively, fatigue test results may be required.

4.10 Shrink fit of semi-built crankshafts

4.10.1 The maximum permissible internal diameter in the journal pin is to be calculated in accordance with the following formula:

$$D_{ji} = D_s \sqrt{1 - \frac{4000 FoS\, M_{max}}{\mu \pi D_s^2 L_s \sigma_{yj}}} \text{ mm}$$

where the symbols are as defined in 4.10.7.

4.10.2 When 4.10.1 cannot be complied with, then 4.10.7 is not applicable. In such cases δ_{min} and δ_{max} are to be established from FEM calculations.

~~*4.10.1*~~ *4.10.3* The following formulae are applicable to crankshafts assembled by shrinking main journals into the crankwebs.

~~*4.10.2*~~ *4.10.4* In general, the radius of transition, R_j, between the main journal diameter, D_j, and the shrink diameter, D_s, is to be not less than $0{,}015D_j$ or $0{,}5(D_s - D_j)$.

~~*4.10.3*~~ *4.10.5* The distance, y, between the underside of the pin and the shrink diameter should be greater than $0{,}05D_s$.

~~*4.10.4*~~ *4.10.6* Deviations from these parameters will be specially considered.

~~*4.10.5*~~ *4.10.7* The proposed diametral interference is to be within the following limits (*see also* ~~Fig. 1.4.2~~ Fig. 1.4.4):

The minimum required diametral interference is to be taken as the greater of:

$$\delta_{min} = \frac{12{,}156 \times 10^6 (FoS)}{T\, \cancel{D_s}\, D_s\, \mu\, E} \; \frac{P}{R} (1 + C) \; \frac{k^2 - l^2}{(k^2 - 1)(1 - l^2)} \text{ mm}$$

or

$$\delta_{min} = \frac{\sigma_y D_s}{E} \text{ mm}$$

where

h = minimum radial thickness of the web around the diameter D_s, mm
$k = \dfrac{D_o}{D_s}$
$l = \dfrac{D_{ji}}{D_s}$
C = ratio of torsional vibratory torque to the mean transmitted torque at the P/R rating being considered
$D_o = D_s + 2h$, mm
D_s = shrink diameter, in mm
E = Young's modulus of elasticity of crankshaft material, N/mm^2
FoS = Factor of Safety against rotational slippage to be taken as 2,0. A value less than 2,0 may be used where documented by experiments to demonstrate acceptability
P = output power, in kW
R = speed at associated power, in rpm
T = crankweb thickness, in mm
μ = coefficient of static friction to be taken as 0,2 for degreased surfaces provided $T/D_s > 0{,}4$. A value greater than 0,2 may be used where documented by experiments to demonstrate acceptability
σ_{yj} = minimum yield strength of material for journal pin
M_{max} = absolute maximum value of the torque taking Ch 8,2 into consideration
L_s = length of shrink fit, in mm

Maximum diametral interference, δ_{max}. is not to be greater than:

$$\delta_{max} = \frac{\sigma_y D_s}{E} + \cancel{\frac{1{,}8D_s}{1000}} \; \frac{0{,}8D_s}{1000} \text{ mm}$$

~~*4.10.6*~~ *4.10.8* Reference marks are to be provided on the outer junction of the crankwebs with the journals.

Existing Fig. 1.4.2 *has been renumbered* Fig. 1.4.4.

■ *Section 6*
Safety arrangements on engines

6.1 Cylinder relief valves

~~*6.1.1* Cylinder relief valves are to be fitted to engines having cylinders over 230 mm bore. The valves are to be loaded to not more than 40 per cent above the designed maximum pressure and are to discharge where no damage can occur.~~

~~*6.1.2*~~ *6.1.1* Scavenge spaces in open connection with cylinders are to be provided with explosion relief valves. The valves are to be arranged and positioned on engines to minimise the possibility of danger and damage arising from emission from the valves.

■ *Section 8*
Piping systems

8.2 Oil fuel systems

8.2.6 Where multi-engined installations are supplied from the same fuel source, means of isolating the fuel supply and spill piping to individual engines is to be provided. These means of isolation are not to affect the operation of the other engines and are to be operable from a position not rendered inaccessible by a fire on any of the engines, *see also* Pt 1, ~~Ch 2,4.14~~ Ch 2,4.15.

8.6 Intake and exhaust systems

8.6.1 The air intakes and exhausts are to be in accordance with the engine manufacturer's design and installation requirements. Particular attention is drawn to the requirements on pressure and flow conditions to be achieved throughout the intake and exhaust systems. The arrangements are to comply with 8.6.2 to 8.6.10 as applicable.

Existing paragraphs 8.6.1 *to* 8.6.9 *have been renumbered* 8.6.2 *to* 8.6.10.

■ *Section 9*
Control and monitoring

9.3 Electrical generator and auxiliary engine speed governors

9.3.5 Where the electrical system power supply requirements are to comply with STANAG 1008 ~~and the electrical class notation **ELS** is required~~, the requirements in 9.3.6 to 9.3.8 are also applicable. Alternative performance characteristics may be accepted where transient stability analysis required by Pt 10, Ch 1,1.8 has been submitted for consideration and accepted by Lloyd's Register (hereinafter referred to as 'LR').

CORRIGENDUM

■ *Section 15*
Electronically controlled engines

15.5 FMEA analysis

(*Part only shown*)
15.5.1 Failure Mode and Effects Analysis (FMEA) is to demonstrate that a failure of the functioning of an electronic control system:

(c) Will not leave either the engine, or any equipment or machinery associated with the engine, or the ship in an unsafe condition (*see* Pt 9, Ch 1,2.3.12, 2.4.5, 2.5.4, ~~2.9.3~~ 2.9.4, 2.12.5).

Volume 2, Part 2, Chapter 2
Gas Turbines

CORRIGENDUM

■ *Section 1*
General requirements

1.5 Inclination of vessel

1.5.1 Gas turbines are to operate satisfactorily under the conditions of inclinations as shown in ~~Table 2.4.1~~ Table 2.4.2 in Pt 1, Ch 2.

Effective date 1 January 2007

■ *Section 4*
Design and construction

4.4 Intake and exhaust ducts

4.4.1 The air intakes and exhausts ~~uptakes~~ are to be in accordance with the turbine manufacturer's design requirements. Particular attention is drawn to the requirements on pressure and flow conditions to be achieved throughout the intake and exhaust ~~uptake~~ systems. Arrangements are to comply with 4.4.2 to ~~4.4.8~~ 4.4.9 as applicable.

■ *Section 7*
Control, alarm and safety systems

7.3 Speed governors

7.3.5 Where the electrical system power supply requirements are to comply with STANAG 1008 ~~and the electrical class notation **ELS** is applicable~~, the requirements of 7.3.6 or 7.3.7 are also applicable. Alternative performance characteristics may be accepted where a transient stability analysis required by Pt 10, Ch 1,1.8 has been submitted for consideration and accepted by LR.

Volume 2, Part 2, Chapter 3

Steam Turbines

CORRIGENDUM

■ *Section 1*
General requirements

1.4 Inclination of ship

1.4.1 Main and essential auxiliary steam turbines are to operate satisfactorily under the conditions as shown in ~~Table 2.4.1~~ Table 2.4.2 in Pt 1, Ch 2.

Effective date 1 January 2007

■ *Section 5*
Emergency arrangements

5.2 Single screw ships

5.2.1 In single screw ships fitted with cross compound ~~main~~ steam turbine installations in which two or more turbines are separately coupled to the same main gear wheel, the arrangements are to be such as to enable safe navigation when the ~~that~~ steam supply is ~~can be~~ led direct to the L.P. turbine and either the H.P or I.P. turbine can exhaust direct to the condenser. Adequate arrangements and controls are to be provided for these emergency operating conditions so that the pressure and temperature of the steam will not exceed those which the turbines and condenser can safely withstand.

5.2.2 The necessary pipes and valves or fittings for these arrangements are to be readily available and properly marked. A fit up test of all combinations of pipes and valves is to be performed prior to the first sea trials.

5.2.3 The permissible power/speeds of the operating turbines(s) when operating without one of the turbines (all combinations) is to be specified and information provided on board.

5.2.4 The operation of the turbines under emergency conditions is to be assessed for the potential influence on shaft alignment and gear teeth loading conditions.

Volume 2, Part 3, Chapter 2

Shafting Systems

Effective date 1 January 2007

■ *Scope*

The requirements of this Chapter relate, in particular, to formulae for determining the diameters of shafting for main propulsion installations, but requirements for couplings, coupling bolts, keys, keyways, sternbushes and other associated components are also included. The diameters may require to be modified as a result of alignment considerations and vibration characteristics, *see* Part 5, or the inclusion of stress raisers, other than those contained in this Chapter.

Alternative calculation methods for determining the diameters of shafting for main propulsion and their permissible torsional stresses will be considered by LR. Any alternative calculation method is to include all relevant loads on the complete dynamic shafting system under all permissible operating conditions. Consideration is to be given to the dimensions and arrangements of all shaft connections. Moreover, an alternative calculation method is to take into account design criteria for continuous and transient operating loads (dimensioning for fatigue strength) and for peak operating loads (dimensioning for yield strength). The fatigue strength analysis may be carried out separately for different load assumptions, for example as given below.

Shafts complying with the applicable Rules in this Chapter and Part 5 satisfy the following:
(a) Low cycle fatigue criterion (typically $<10^4$), i.e. the primary cycles represented by zero to full load and back to zero, including reversing torque if applicable. This is addressed by the formulas in 4.2, 4.4 and 4.5.
(b) High cycle fatigue criterion (typically $>>10^7$), i.e. torsional vibration stresses permitted for continuous operation as well as reverse bending stresses and the accumulated fatigue due to torsional vibration when passing through a barred speed range or any other transient condition with associated stresses beyond those permitted for continuous operation. This is addressed by the formulas in Pt 5, Ch 1,3.2. The influence of reverse bending stresses is addressed by the safety margins inherent in the formulas in 4.2, 4.4 and 4.5.

■ *Section 1*
General requirements

1.1 Application

~~*1.1.2* This Chapter gives the requirements for the dimensions of transmission shafts, couplings, coupling bolts, keys, keyways, sternbushes and other associated components of main propulsion shafting.~~

~~*1.1.3* The diameters may require to be modified as a result of alignment considerations and vibration characteristics (*see* Part 5), or the inclusion of stress raisors, other than those contained in this Chapter.~~

~~*1.1.4*~~ *1.1.2* For shafting enclosed within an gearbox, *see* Ch 1,7.

~~*1.1.5*~~ *1.1.3* For diesel engine crankshaft and turbine rotor shafting, *see* Pt 2, Ch 1, Ch 2 and Ch 3.

■ *Section 2*
Particulars to be submitted

2.2 Calculations and specifications

2.2.1 The following calculations and specifications are to be submitted:

- Calculations, or relevant documentation indicating the suitability of all components for short term high power operation, where applicable.
- Where undertaken as an alternative to the requirements to this Chapter, fatigue endurance calculations of all components according to Pt 1, Ch 2.
- Vibration analysis and alignment analysis as required by Part 5.
- The material specifications, including the minimum specified tensile strength of each shaft and coupling component is to be stated. Where corrosion resistant material not included in Table 2.4.1 is used for unprotected screwshafts the corrosion fatigue strength in sea-water is to be stated together with the chemical composition and mechanical properties.
- Where it is proposed to use composite (non-metallic) shafts, details of materials, resin, lay-up procedure and documentary evidence of fatigue endurance strength.
- For water lubricated bearings in sternbushes and sterntubes, details of the piping system and means for verifying that the required water flow specified by the bearing manufacturers is being maintained. *See also* 4.16.

■ *Section 3*
Materials

3.1 Materials for shafts

~~*3.1.2* Where it is proposed to use alloy steel forgings, particulars of the chemical composition, mechanical properties and heat treatment are to be submitted for approval. For main propulsion shafting, not exposed to sea-water, in alloy steels, the specified minimum tensile strength is not to exceed 800 N/mm^2 and for other forgings is not to exceed 1100 N/mm^2.~~

3.1.2 The specified minimum tensile strength of forgings for shafts is to be selected within the following general limits:

(a) Carbon and carbon-manganese steel – 400 to 760 N/mm^2 (41 to 77,5 kgf/mm^2). *See also* 4.4.1.

(b) Alloy steel – not exceeding 800 N/mm^2 (82 kgf/mm^2) and for other forgings not exceeding 1100 N/mm^2.

3.1.3 Where it is proposed to use alloy steel, details of the chemical composition, heat treatment and mechanical properties are to be submitted for approval.

3.1.4 Where shafts may experience vibratory stresses close to the permissible stresses for transient operation, the materials are to have a specified minimum tensile strength of 500 N/mm^2 (51 kgf/mm^2).

3.1.5 Where materials with greater specified or actual tensile strengths than the limitations given above are used, reduced shaft dimensions or higher permissible vibration stresses are not acceptable when derived from the formulae used in 4.2, 4.4, 4.5 and Pt 5, Ch 1,3.2.

~~*3.1.3*~~ *3.1.6* Unprotected screwshafts and tubeshafts exposed to sea-water are in general to be manufactured, from corrosion resistant ferrous or non-ferrous material, such as those indicated in Table 2.4.1.

~~*3.1.4*~~ *3.1.7* In the selection of materials for shafts, keys, locking nuts etc., consideration is to be given to their compatibility with the proposed propeller material.

~~*3.1.5*~~ *3.1.8* Where shafts are manufactured from composite material the process is to be approved.

■ *Section 4*
Design and construction

4.2 Intermediate shafts

4.2.1 The diameter, *d*, of the intermediate shaft is to be not less than that determined by the following formula:

$$d = F\,k\,\sqrt[3]{\frac{P}{R}\left(\frac{560}{\sigma_u + 160}\right)}\ \text{mm}$$

where

k = 1,0 for shafts with integral coupling flanges complying with 4.8 or with shrink fit couplings, *see* 4.2.4

= 1,10 for shafts with keyways, in tapered or cylindrical connections, where the fillet radii in the transverse section of the bottom of the keyway are not less than 0,0125*d*, *see* 4.2.5

= 1,10 for shafts with transverse or radial holes where the diameter of the hole (d_h) does not exceed 0,3*d*

= 1,20 for shafts with longitudinal slots *see* 4.2.6 ~~having a length of not more than 1,4*d* and a width of not more than 0,2*d* where *d*, is determined with *k* = 1,0~~

F = 95 for turbine installations, electric propulsion installations and diesel engine installations with slip type couplings

= 100 (90,5) for other diesel engine installations

P and *R* are defined in Pt 1, Ch 2,4.3.1 (losses in gearboxes and bearings are to be disregarded)

σ_u = specified minimum tensile strength of the shaft material, in N/mm^2 (kgf/mm^2), *see* 3.1.2.

4.2.4 For shrink fit couplings *k* refers to the plain shaft section only. Where shafts may experience vibratory stresses close to the permissible stresses for continuous operation, an increase in diameter to the shrink fit diameter is to be provided, e.g. a diameter increase of 1 to 2 per cent and a blending radius as described in 4.8.

4.2.5 Keyways are in general not to be used in installations with a barred speed range.

4.2.6 The application of *k* = 1,20 is limited to shafts with longitudinal slots having a length of not more than 0,8*d* and a width of not more than 0,1*d* and a diameter of central hole d_i of not more than 0,8*d*, *see* 4.5. The end rounding of the slot is not to be less than half the width. An edge rounding should preferably be avoided as this increases the stress concentration slightly. The values of c_K, *see* Table 1.3.1 in Pt 5, Ch 1, are valid for 1, 2 and 3 slots, i.e. with slots at 360, 180 and 120 degrees apart respectively.

4.3 Thrust shafts external to engines

4.3.1 The diameter at the collars of the thrust shaft transmitting torque or in way of the axial bearing where a roller bearing is used as a thrust bearing is to be not less than that required for the intermediate shaft in accordance with 4.2 with a *k* value of 1,10. Beyond a length equal to the thrust shaft diameter from the collars, the diameter may be tapered down to that required for the intermediate shaft with a *k* value of 1,0. For the purpose of the foregoing calculations, σ_u is to be taken as the minimum tensile strength of the thrust shaft material, in N/mm^2. The fillet radius at the base of both sides of the thrust collar is to be not less than 0,08 of the diameter of the shaft at the collar.

4.4 Screwshafts and tube shafts

4.4.3 The diameter, d_p of the protected forged steel screwshaft immediately forward of the forward face of the propeller boss or, if applicable, the forward face of the screwshaft flange, is to be not less than:

$$d_p = 100\,k\,\sqrt[3]{\frac{P}{R}\left(\frac{560}{\sigma_u + 160}\right)}\ \text{mm}$$

where

k = 1,22 for a shaft carrying a keyless propeller fitted on a taper, or where the propeller is attached to an integral flange, and where the shaft is fitted with a continuous liner, a coating of an approved type, or is oil lubricated and provided with an approved type of oil sealing gland

= 1,26 for a shaft carrying a keyed propeller and where the shaft is fitted with a continuous liner, a coating of an approved type, or is oil lubricated and provided with an approved type of oil sealing gland

σ_u = specified minimum tensile strength of the shaft material, in N/mm^2 but is not to be taken as greater than 600 N/mm^2.

4.4.5 The diameter of the portion of the screwshaft and tube shaft forward of the length required by 4.4.4 to the forward end of the forward stern tube seal is to be determined in accordance with 4.4.3 with a k value of 1,15. The change of diameter from that determined with k = 1,22 or 1,26 to that determined with k = 1,15 should be gradual, *see* 4.8.

4.4.6 Screwshafts which run in sterntubes and tube shafts may have the diameter forward of the forward stern tube seal gradually reduced to the diameter of the intermediate shaft. Abrupt changes in shaft section at the screwshaft/tube shaft to intermediate shaft couplings are to be avoided, *see* 4.8.

4.8 Flange connections of couplings

4.8.6 Transitions of diameters are to be designed with either a smooth taper or a blending radius. In general, a blending radius equal to the change in diameter is recommended.

Volume 2, Part 4, Chapter 1

Propellers

Effective date 1 January 2007

■ *Section 6* Materials

6.1 Castings for propellers

6.1.3 Spheroidal cast iron load transmitting components of controllable pitch mechanisms, are to be manufactured, tested and certified in accordance with Chapter 7 of the Rules for Materials, and have an elongation of not less than 12 per cent.

Volume 2, Part 4, Chapter 4

Podded Propulsion Units

Effective date 1 January 2007

■ *Section 1* Scope

1.1 Application

1.1.1 This Chapter applies to podded propulsion units where used for propulsion, ~~DP~~ dynamic positioning duty or as the sole means of steering.

1.1.4 The structural requirements stated in 5.1, 5.2 and 5.3 relate to podded propulsion units having a ~~conventional cylindrical~~ pod body with single supporting strut with or without an integral slewing ring arrangement, *see* Fig. 4.1.1. Novel and unconventional arrangements will be subject to individual consideration. In such cases, the designers are advised to contact LR in the early stages of the design for advice on the manner and content of design information required for formal classification appraisal.

1.1.7 It is the shipbuilder's responsibility to ensure that all installed equipment is suitable for operation in the location and under all anticipated environmental conditions associated with the design of the ship which is to include temperature, humidity, vibration and impulsive accelerations.

■ *Section 2* General requirements

2.2 Plans and information to be submitted

2.2.1 In addition to the plans required by Pt 3, Ch 1 and Ch 2, Pt 4, Ch 1, Pt 5, Pt 6, Ch 1, Pt 7, Ch 3 and Parts 9 and 10, the following plans and information are required to be submitted for appraisal:

(a) Description of the ship’s purpose/capabilities together with the pod’s intended operational modes in support of these capabilities. The operational modes are to include stopping the vessel and restrictions on steering angles at different ship speeds. *See also* ~~(f)~~ (g).

(b) Power transmitted at MCR condition (shaft power and rpm) and other maximum torque conditions, e.g. bollard pull.

(c) Maximum transient thrust, torque and other forces and moments experienced during all envisaged operating modes as permitted by the steering and propulsor drive control systems.

~~(c)~~ (d) Details of the electric propulsion motor short-circuit torque and motor air gap tolerance.

~~(d)~~ (e) Sectional assembly in the Z-X plane, *see* Fig. 4.2.1.

~~(e)~~ (f) Specifications of materials and NDE procedures for components essential for propulsion and steering operation, to include propulsion shaft and slewing ring bearings, gearing and couplings, *see* 4.1.

~~(f)~~ (g) Details of intended manoeuvring capability of the ship in each operating condition. (To be declared by the Naval Authority, *see also* 3.1.1).

~~(g)~~ (h) Design loads for both the pod structure and propeller together with podded propulsion unit design operating modes (*see* 2.4.1, 6.3.7, 6.6.5 and 6.6.6).

~~(h)~~ (j) Supporting data, calculations and direct calculation reports. This is to include an assessment of anticipated global accelerations acting on the ship's machinery and equipment which may potentially affect the reliable operation of the propulsion system. *See also* 1.1.5.

~~(i)~~ (k) Structural component details including: strut, pod body, bearing supports, bearing end caps, ship's structure in way of podded propulsion unit integration and a welding Table showing a key to weld symbols used on the plans specifying weld size, type, preparation and heat treatment. The information should include the following:

- Detailed drawings showing the structural arrangement, dimensions and scantlings.
- Welding and structural details.
- Connections between structural components (bolting).
- Casting's chemical and mechanical properties.
- Forging's chemical and mechanical properties.
- Material grades for plate and sections.

~~(k)~~ (l) Nozzle ring structure and nozzle support details if applicable to the application.

~~(l)~~ (m) Propeller shaft bearing mounting and housing arrangement details, *see also* 6.3.6.

~~(m)~~ (n) Details of propeller shaft and steering bearings, where roller bearings are used supporting calculations are to be submitted, see 6.3.7 and 6.6.6.

~~(n)~~ (o) Propeller shaft seal details.

~~(o)~~ (p) Details of propeller shaft and pod steering securing/locking and means of aligning the securing/locking arrangements.

~~(p)~~ (q) Cooling systems piping system schematic.

~~(q)~~ (r) Details of any lubricating oil conditioning systems (filtering/cooling/heating) and control arrangements necessary to ensure the continuous availability of the required lubricating oil quality to the propeller shaft bearings.

(r) (s) Details of installed condition monitoring equipment.

(s) (t) Details of the derivation of any duty factor used in the design of the steering gears.

~~(t)~~ (u) Recommended installation, inspection ~~and~~ maintenance and component replacement procedures (*see also* 5.1.2). This is to include any in-water/underwater engineering procedures where recommended by the pod manufacturer. *See also* 6.5.7 and Section 10.

~~(u)~~ (v) Identification of any potentially hazardous atmospheric conditions together with details of how the hazard will be countered, this should include a statement of the maximum anticipated air temperature within the pod during full power steady state operation, *see* 2.3.

~~(v)~~ (w) Access and closing arrangements for pod unit inspection and maintenance.

~~(w)~~ (x) Heat balance calculations for the pod unit taking into account electrical thermal riser when the pod is operating at maximum continuous operating conditions, heat transfer and maximum sea-water/air temperatures, *see* 6.7.4.

~~(x)~~ (y) Details of proposed testing and trials required by Section 9.

~~(y)~~ (z) Details of emergency steering and pod securing arrangements, *see* ~~6.6.8~~ 6.3.11.

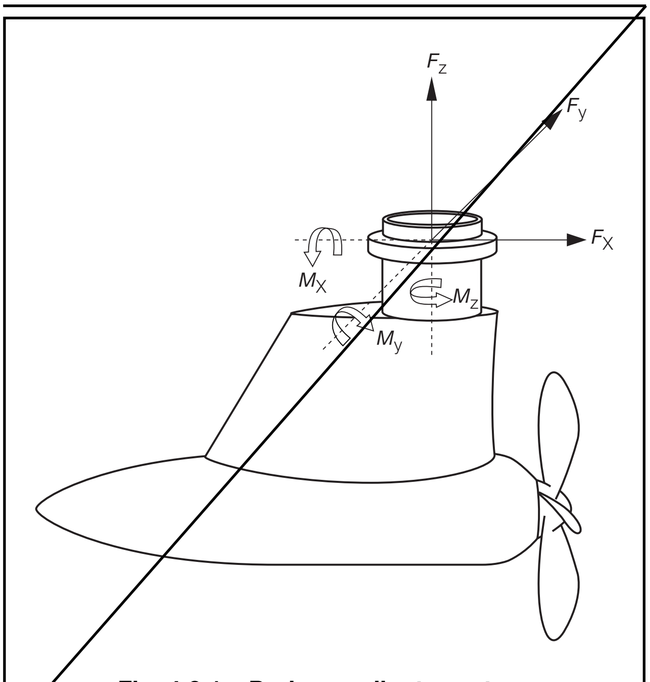


Fig. 4.2.1 Pod co-ordinate system

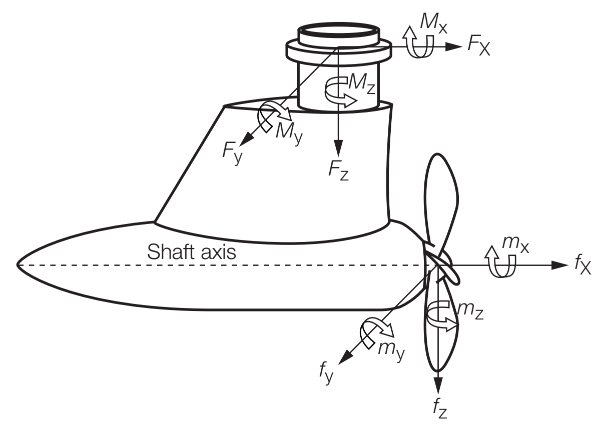


Fig. 4.2.1 Pod co-ordinate system

2.3 Pod internal atmospheric conditions

2.3.1 Machinery and electrical equipment installed within the pod unit are to be suitable for operation, without degraded performance, at the maximum anticipated air temperature and humidity conditions within the pod unit with the pod operating at its maximum continuous rating in sea water of not less than 32°C after steady state operating conditions have been achieved.

2.4 Global loads

2.4.1 The overall strength of the podded propulsion unit structure is to be based upon the maximum anticipated in-service loads, including, ~~where necessary,~~ the effects ~~from~~ of ship manoeuvring and of ship motion (*see* Table 3.2.1 in Vol 1, Pt 5, Ch 3). This is to include the effects of any pod to pod and/or pod to ship hydrodynamic interference effects. The designer is to supply the following maximum load and moment values to which the unit may be subjected with a description of the operating condition at which they occur:

- F_x, Force in the longitudinal direction;
- F_y, Force in the transverse direction;
- F_z, Force in the vertical direction including self weight, in water, augmented by the ship's pitch and heave motion and flooded volume where applicable, *see* 5.3.3 and Vol 1, Pt 5, Ch 3;
- M_x, moment at the slewing ring about the pod unit's global longitudinal axis;
- M_y, moment at the slewing ring about the pod unit's global transverse axis;
- M_z, moment at the slewing ring about the pod unit's vertical axis (maximum dynamic duty steering torque on steerable pods).

The directions of the X, Y and Z axes, with the origin at the centre of the slewing ring, are shown in Fig. 4.2.1.

2.4.2 Where the maximum loads and moments described in 2.4.1 cannot be readily identified from calculation methods or are based on model testing, the estimated loads and moments are to be stated at pod unit steering angular intervals of 5 degrees over the range from ahead to astern for the relevant combinations of shaft rotational and ship speed. In the case of pod to pod and/or pod to ship hydrodynamic interaction effects these must be defined for the most severely affected propulsor including cases where pod units are capable of being independently steered.

■ *Section 3*
Functional capability

3.1 General

3.1.2 In general, the steering mechanism is to be capable of turning the pod between the declared steering angle limits at an average rotational speed of not less than 0,4 rev/min with the ship initally operating at its maximum ahead service speed.

■ *Section 4*
Materials

4.1 General

~~*4.1.1* The specification for materials required by 2.2.1(e) is to cover the pod body, strut, gearing, shafts, couplings and propeller, with details of chemical composition, heat treatment and mechanical properties. Where a combination of different materials is proposed for the structural arrangement, LR is to be advised in the early stages of the design process to identify material and NDE requirements.~~

~~*4.1.2* The materials used for the major structural and machinery components of the podded drive unit are to be manufactured and tested in accordance with the requirements of Vol 1, Part 2. Materials for which provision is not made therein may be accepted, provided that they comply with an approved specification and such tests as may be considered necessary.~~

~~*4.1.3* Materials for machinery and system components are also to comply with the requirements from the relevant chapters of the Rules.~~

~~*4.1.4* Where load carrying threaded fasteners screw directly into structural castings, the material integrity of the casting is to be such that there is no porosity in the area of the connection.~~

~~*4.1.5* Castings and forgings are to be subject to non-destructive examination in accordance with the relevant sections of the Rules for Materials.~~

~~*4.1.6* For components of novel design, the material test and non-destructive examination requirements will be subject to evaluation by LR.~~

4.1.1 The materials used for major structural and machinery components are to be manufactured and tested in accordance with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials* (hereafter referred to as the Rules for Materials). These components include hull support structure, pod body, pod strut, shafting and propellers.

4.1.2 Components of novel design or components manufactured from materials not covered by the Rules for Materials are to be subject to evaluation and approval by LR prior to manufacture.

4.1.3 Material specifications, *see* 2.2.1(f), for propulsion shaft and slewing ring bearings, gearing and couplings are to be approved by LR prior to manufacture. The specification is to include details of the grade of material, including the target range of chemical composition that is to be reported on the certificate, the required mechanical properties, heat treatment details including temperatures and hold times, details of necessary non-destructive examinations including acceptance levels. Additionally, any steel cleanness or microstructure requirements are to be included. These components are to be manufactured under survey.

4.1.4 For propulsion shaft rolling element bearings the amount of retained austenite is to be determined and is not to exceed 4 per cent for nominally bainitic structures.

4.1.5 Where load carrying threaded fasteners screw directly into structural castings, the integrity of the casting is to be such that there is no porosity or shrinkage in the area of the connection.

■ *Section 5*

Structure design and construction requirements

5.1 Pod structure

5.1.2 Means are to be provided to enable the propeller shaft, bearings and seal to be fully examined in accordance with the manufacturer's recommendations at docking Survey to the Surveyor's satisfaction.

5.1.5 The strut is to have a smooth transition from the upper mounting to the lower hydrodynamic~~ally~~ ~~adapted sectional shapes~~ sections.

5.2 Hull support structure

5.2.1 For supporting the main slewing bearing outer races, a system of primary structural members is to be provided in order to transfer the maximum design loads and moments from the podded propulsion unit into the ship's hull without undue deflection. Due account is also to be taken of the loads induced by the maximum ship's motions in the vertical direction resulting from combined heave and pitch motion of the ship. Account is also to be taken of any manoeuvring conditions that are likely to give rise to high mean or vibratory loadings induced by the podded propulsion unit. *See* 2.2.1(c).

5.3 Direct calculations

5.3.4 Based on the most onerous combination of normal service loading conditions, the stress criteria shown in Table 4.5.2 are not to be exceeded. *See also* 2.2.1(c).

■ *Section 6*

Machinery design and construction requirements

6.3 Propulsion shafting

6.3.2 ~~Critical motor speeds which may result in significant vibration amplitudes are to be sufficiently removed from the shaft running speed that there will be no significant lateral vibration response within ± 20 per cent of the running speed.~~ There is to be no significant lateral vibration response that may cause damage to the shaft seals within ±20 per cent of the running speed range. For vibration analysis computations the influence of the slewing ring and shaft bearing stiffnesses together with the contribution from the seating stiffnesses are to be included in the calculation procedures.

6.3.6 The arrangement of shaft bearings is to take account of shaft thermal expansion, misalignment of bearings, shaft slope through the bearings and manufacturing tolerances. Additionally, the influence of the pod deflection on the shaft bearing alignment is to be considered under the most onerous mechanical and hydrodynamic loading conditions.

6.3.7 Propeller shaft roller bearing life calculations are to take account of the following loadings:

- Shaft, motor, propeller and other shaft appendages' weights;
- Forces due to ship's motion;
- ~~Offset thrust loads from the propeller;~~
- The propeller-generated forces and moments about the three Cartesian axes related to the shaft; f_x, f_y, f_z, m_x, m_y, m_z, *see* Fig. 4.2.1;
- Variance of ~~thrust, thrust offset and side load~~ propeller-generated forces and moments with pod azimuth angle. This load variance should take account of the motor control characteristics;
- Forces due to pod rotation, including gyroscopic forces;
- A predicted azimuth service profile for the pod indicating the proportion of time spent at various azimuth angles;
- Loads due to hydrodynamic interaction between pods;
- Any additional loads experienced during operation in ice conditions (for Ice Class notations);
- Where validation of the above loadings is available, detailed calculations must demonstrate that the bearing life when operating at the normal duty profile will comfortably exceed the time between 6-yearly surveys. Parameters used to justify the bearing life, i.e. those related to oil cleanliness, viscosity limits and material quality are to be quoted.

6.3.9 The design of the shaft line bearings is to take account of the maximum and minimum operating temperatures likely to be encountered during both a voyage cycle and, more widely, during the ship's operational life. Furthermore, any anticipated temperature distributions through the bearing components and structures are to be included in the design calculations.

Existing paragraph 6.3.9 *has been renumbered* 6.3.10.

~~6.3.10~~ 6.3.11 On multi podded ships, means are to be provided to hold the propeller on an inoperable unit stationary whilst the other pod(s) propel the vessel at a manoeuvring speed of not less than 7 knots. Operating instructions displayed at the holding mechanism's operating position are to include a direction to inform the bridge of any limitation in ships speed required as a result of the holding mechanism being activated.

Existing paragraphs 6.3.11 *and* 6.3.12 *have been renumbered* 6.3.12 *and* 6.3.13.

6.5 Bearing lubrication system

6.5.7 The procedures for flushing the lubrication system are to be defined. This procedure is to embrace the following conditions:
(a) Initial installation.
(b) Post maintenance situations.
(c) Major dry-docking refits.
See Section 10.

6.6 Steering system

6.6.8 On multi podded ships, means are to be provided to secure each pod unit's slewing mechanism in its ahead or zero degree ~~mid~~ position in the event of a steering system failure. These arrangements are to be of sufficient strength to hold the pod in position at the ship's manoeuvring speed to be taken as not less than 7 knots (*see also* 6.3.9). Operating instructions displayed at the securing mechanism's operating position are to include a direction to inform the bridge of any limitation in ships speed required as a result of the securing mechanism being activated.

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6.7 Ventilation and cooling systems

6.7.4 For pods having an electric propulsion motor but no active cooling system, heat balance calculations as required by ~~2.2.1(w)~~ 2.2.1(x) are to demonstrate that the pod unit and associated systems are able to function satisfactorily over all operating conditions, *see* Pt 1, Ch 2,4.4.

6.8 Pod drainage requirements

6.8.2 Two independent means of drainage are to be provided so that liquid leakage may be removed from the pod unit at all design angles of heel and trim, *see* Pt 1, ~~Ch 2,4.5~~ Ch 2,4.6.

Effective date 1 January 2007

■ *Section 8*
Control engineering arrangements

8.1 General

8.1.7 Where a propulsion system which includes a podded propulsor unit is controlled by a series of interactive and integrated programmable electronic systems, then these are to comply with the requirements of Vol 2, Pt 9, Ch 1,2.12.

8.2 Monitoring and alarms

8.2.6 Condition monitoring arrangements are not to interface with the operation of safety systems which may cause slow-down or shut-down of the propulsion system. *See also* Pt 9, Ch 1,2.6.9.

■ *Section 10*
Installation, maintenance and replacement procedures

10.1 General

10.1.1 All podded propulsion units are to be supplied with a copy of the manufacturer's installation and maintenance manual that is pertinent to the actual equipment. *See* 2.2.1(u).

10.1.2 The manual required by 10.1.1 is to be placed on board and is to contain the following information:
(a) Description of the podded propulsion unit with details of function and design operating limits. This is also to include details of support systems such as lubrication, cooling and condition monitoring arrangements.
(b) Identification of all components together with details of any that have a defined maximum operating life.
(c) Instructions for installation of unit(s) on board ship with details of any required specialised equipment.
(d) Instructions for commissioning at initial installation and following maintenance.
(e) Maintenance and service instructions to include inspection/renewal of bearings, seals, motors, slip rings and other major components. This is also to include component fitting procedures, special environmental arrangements, clearance and push-up measurements and lubricating oil treatment where applicable.
(f) Actions required in the event of fault/failure conditions being detected.
(g) Precautions to be taken by personnel working during installation and maintenance.

Volume 2, Part 5, Chapter 1

Torsional Vibration

Effective date 1 January 2007

■ *Section 2* Details to be submitted

2.2 Scope of calculations

2.2.3 The calculations carried out on oil engine systems are to be based on the Enginebuilders' harmonic torque data. (On request, Lloyd's Register (hereinafter referred to as 'LR') can provide a table of generalised harmonic torque components for use where appropriate.) The calculations are to take account of the effects of engine malfunction commonly experienced in service, such as a cylinder not firing (i.e. no injection but with compression) giving rise to the highest torsional vibration stresses in the shafting. Calculations are also to take account of a degree of imbalance between cylinders, characteristic of the normal operation of an engine under service conditions.

■ *Section 3* Design

3.1 Symbols and definitions

3.1.1 The symbols used in this Section are defined as follows:

d = minimum diameter of shaft considered, in mm
d_{i} = diameter of internal bore, in mm
r = ratio N/N_{s} or $N_{\mathrm{c}}/N_{\mathrm{s}}$ whichever is applicable
N = engine speed, in rev/min
N_{c} = critical speed, in rev/min
N_{s} = maximum continuous engine speed, in rev/min, or, in the case of constant speed generating sets, the full load speed, in rev/min
Q_{s} = rated full load mean torque, in N mm
τ_{c} = maximum value of the vibration stress for continuous running at or below the maximum speed, in N/mm^2
permissible stress due to torsional vibrations for continuous operation, in N/mm^2
τ_{t} = permissible stress due to torsional vibrations for transient operation, in N/mm^2
σ_{u} = specified minimum tensile strength of the shaft material, in N/mm^2
C_{k} = a factor for different shaft design features, *see* Table 1.3.1
C_{d} = a size factor defined as $0{,}35 + 0{,}93d^{-0{,}2}$
k = the factor used in determining minimum shaft diameter, defined in Pt 3, Ch 2,4.2.1 and 4.4.3
e = slot width, in mm
l = slot length, in mm.

~~**Table 1.3.1 C_{k} factors**~~

~~For intermediate shafts with~~			~~For thrust shafts external to engines~~		~~For propeller shafts~~
~~Integral coupling flanges~~	~~Shrink fit couplings~~	~~Keyways~~	~~On both sides of thrust collar~~	~~In way of axial bearing where a roller bearing is used as a thrust bearing~~	~~For which k = 1,22 and = 1,26~~
~~1,0~~	~~1,0~~	~~0,60~~	~~0,85~~	~~0,85~~	~~0,55~~

~~NOTE~~
~~The determination of C_{k} – factors for shafts other than shown in this Table is at the discretion of LR.~~

Table 1.3.1 C_{k} factors

Intermediate shafts with	
Integral coupling flange and straight sections	1,0
Shrink fit coupling	1,0
Keyway, tapered connection	0,60
Keyway, cylindrical connection	0,45
Radial hole	0,50
Longitudinal slot	0,30 (*see* 3.1.4)
Thrust shafts external to engines	
On both sides of thrust collar	0,85
In way of axial bearing where a roller bearing is used as a thrust bearing	0,85
Propeller shafts	
Flange mounted or keyless taper fitted propellers	0,55
Key fitted propellers	0,55
Between forward end of aft most bearing and forward stern tube seal	0,80

NOTE
The determination of C_{k} – factors for shafts other than shown in this Table will be specially considered by LR.

3.1.4 For a longitudinal slot c_{k} = 0,3 is applicable within the dimension limitations given in Vol 2, Pt 3, Ch 2,4.2.6. If the slot dimensions are outside these limitations, or if the use of another c_{k} is desired, the actual stress concentration factor (*scf*) is to be documented or determined from 3.1.5, in which case:

$$c_{\mathrm{k}} = \frac{1{,}45}{scf}$$

Note that the *scf* is defined as the ratio between the maximum local principal stress and $\sqrt{3}$ times the nominal torsional stress (determined for the bored shaft without slots).

3.1.5 Stress concentration factor of slots. The stress concentration factor (*scf*) at the ends of slots can be determined by means of the following empirical formulae:

$$scf = \alpha_{t(hole)} + 0{,}57 \; \frac{\dfrac{(l - e_h)}{d}}{\left(1 - \dfrac{d_1}{d}\right)\dfrac{e_h}{d}}$$

This formula applies to:

- Slots at 120 or 180 or 360 degrees apart.
- Slots with semicircular ends. A multi-radii slot end can reduce the local stresses, but this is not included in this empirical formula.
- Slots with no edge rounding (except chamfering), as any edge rounding increases the *scf* slightly.

$\alpha_{t(hole)}$ represents the stress concentration of radial holes and can be determined as:

$$\alpha_{t(hole)} = 2{,}3 - 3\,\frac{e_h}{d} + 15\left(\frac{e_h}{d}\right)^2 + 10\left(\frac{e_h}{d}\right)^2\left(\frac{d_i}{d}\right)^2$$

where

e_h = hole diameter, in mm

or simplified to $\alpha_{t(hole)} = 2{,}3$.

3.2 Limiting stress in propulsion shafting

3.2.4 In general, the tensile strength of the steel used is to comply with the requirements of Pt 3, Ch 2. For the calculation of the permissible limits of stresses due to torsional vibration, σ_u is not to be taken as more than 800 N/mm^2 in the case of alloy steel intermediate shafts ~~and~~ or 600 N/mm^2 in the case of carbon and carbon-manganese steel intermediate, thrust and propeller shafts.

3.6 Restricted speed and/or power ranges

3.6.1 Restricted speed and/or power ranges will be imposed to cover all speeds where the stresses exceed the limiting values, τ_c, for continuous running, including one-cylinder misfiring conditions if intended to be continuously operated under such conditions. For controllable pitch propellers with the possibility of individual pitch and speed control, both full and zero pitch conditions are to be considered. Similar restrictions will be imposed, or other protective measures required to be taken, where vibratory torques or amplitudes are considered to be excessive for particular machinery items. At each end of the restricted speed range the engine is to be stable in operation.

3.6.2 The restricted speed range is to take account of the tachometer speed tolerances at the barred speeds.

~~*3.6.2*~~ *3.6.3* Critical responses which give rise to speed restrictions are to be arranged sufficiently removed from the maximum revolutions per minute to ensure that, in general, at $r = 0{,}8$ the stress due to the upper flank does not exceed τ_c.

~~*3.6.3*~~ *3.6.4* ~~Where shafting stresses due to a torsional critical response exceed the limiting values, τ_e, for continuous running, the speed restriction will be from:~~ Provided that the stress amplitudes due to a torsional critical response at the borders of the barred speed range are less than τ_c under normal and stable operating conditions the speed restriction derived from the following formula may be applied:

$$\frac{16}{18 - r}\,N_c \text{ to } \frac{18 - r}{16}\,N_c \text{ inclusive.}$$

Existing paragraphs 3.6.4 *to* 3.6.9 *have been renumbered* 3.6.5 *to* 3.6.10.

3.6.11 There are to be no restricted speed ranges imposed above a speed ratio of $r \geq 0{,}8$ under normal operating conditions.

3.6.12 Restricted speed ranges in one-cylinder misfiring conditions on ships with single engine propulsion are to enable safe navigation whereby sufficient propulsion power is available to maintain control of the ship.

Volume 2, Part 5, Chapter 4

Shaft Alignment

Effective date 1 January 2007

■ *Section 1* General requirements

1.2 Basic requirements

1.2.2 The Builder is to carry out shaft alignment calculations for all installations and to prepare alignment procedures detailing the proposed alignment method and the alignment checks to demonstrate compliance with requirements of this Section.

1.2.4 The shafting systems on naval ships may be required to operate under onerous conditions which may affect the shaft alignment and attention is drawn to Pt 1, Ch 2,3.3.18 regarding operation of machinery outside of its optimum envelope.

■ *Section 2* Details to be submitted

2.1 Particulars to be submitted for approval – Shaft alignment calculations

2.1.1 Shaft alignment calculations are to be submitted to Lloyd's Register (hereinafter referred to as 'LR') for approval for the following shafting systems where the screwshaft has a diameter of 250 mm or greater in way of the aftermost sterntube bearing:

(a) All geared installations.
(b) Installations with one bearing, or less, inboard of the forward sterntube bearing/seal.
(c) Where prime movers or shaftline bearings are installed on resilient mountings.

2.1.2 Shaft alignment calculations are to be submitted to LR for approval for the following shafting systems:

(a) thermal displacements of the bearings between cold static and hot dynamic machinery conditions;
(b) buoyancy effect of the propeller immersion due to the ship's operating draught;
(c) effect of predicted hull deformations over the range of the ship's operating draught, where known;
(d) effect of filling the aft peak ballast tank upon the bearing loads, where known;
~~(d)~~ (e) gear forces, where appropriate, due to prime-mover engagement on multiple-input single-output installations;
~~(e) for multi-engined installations, possible contributions in the mode of operation;~~
(f) propeller offset thrust effects;
~~(g) bearing loading in the horizontal plane, where appropriate; and~~
~~(h)~~ (g) maximum allowed bearing weardown~~, where applicable~~; for water or grease-lubricated sterntube bearings, and its effect on the bearing loads.

2.1.3 The shaft alignment calculations are to state the:

(a) expected bearing loads at light and normal ballast, fully loaded and any other draughts deemed to be part of the ship's operating profile, for the machinery in cold and hot, static and dynamic conditions;
(b) bearing influence coefficients and the deflection, slope, bending moment and shear force along the shaftline;
(c) details of propeller offset thrust~~ effects, where applicable~~;
(d) details of proposed slope-bore of the aftermost sterntube bearing, where applicable;
(e) manufacturer's specified limits for bending moment and shear force at the shaft coupling of the gearbox/prime movers;
(f) estimated bearing weardown rates for water or grease-lubricated sterntube bearings;
(g) ~~origin of findings where the effect of~~ expected hull deformation effects and their origin ~~has been considered~~, *viz.* whether finite element calculations or measured results from sister or similar ships have been used;
(h) anticipated thermal rise of prime movers and gearing units between cold static and hot running conditions; and
(j) the manufacturer's allowable bearing loads.

2.2 Particulars to be submitted for review – Shaft alignment procedure

2.2.1 A shaft alignment procedure is to be submitted for all main propulsion installations detailing, as a minimum, the:

(a) expected bearing loads at light and normal ballast, fully loaded and any other draughts deemed to be part of the ship's operating profile, for the machinery in cold and hot, static and dynamic conditions;
(b) maximum permissible loads for the proposed bearing designs;
(c) design bearing offsets from the straight line;
(d) design gaps and sags;
(e) location and loads for the temporary shaft supports;
(f) expected relative slope of the shaft and the bearing in the aftermost sterntube bearing;
(g) details of slope-bore of the aftermost sterntube bearing, where applied;
~~(h) expected shear forces and bending moments at the forward end flange of the shafting system connecting to the gear output shaft or, for direct drive installations, to the prime mover output flange;~~
~~(i)~~ (h) proposed bearing load measurement technique and its estimated accuracy;
~~(k)~~ (j) jack correction factors for each bearing where the bearing load is measured using a specified jacking technique;
~~(l)~~ (k) proposed shaft alignment acceptance criteria, including the tolerances; and
~~(m)~~ (l) flexible coupling alignment criteria.

For water lubricated bearings in sternbushes and sterntubes, details of the piping system and means for verifying that the required water flow specified by the bearing manufacturers is being maintained. *See also* 4.16.

2.3 Design and installation criteria

2.3.2 Design and installation of the shafting is to satisfy the following criteria:

(a) The Builder is to position the bearings and construct the bearing seatings to minimize the effects of hull deflections under any of the ship's operating conditions with the aim of optimising the bearing load distribution.

(b) Relative slope between the propeller shaft and the aftermost sterntube bearing is, in general, not to exceed 3 x 10^{-4} rad in the static condition.

(c) Sterntube bearing loads are to satisfy the requirements of Pt 3, Ch 2,4.16.

(d) Bearings of synthetic material are to be verified as being within tolerance for ovalilty and straightness, circumferentially and longitudinally, after installation.

(e) The sterntube forward bearing static load is to be sufficient to prevent unloading in all static and dynamic operating conditions, including the transient conditions experienced during manoeuvring turns and during operation in heavy weather.

~~(d)~~ (f) Bearings of synthetic material are to be verified as being within tolerance for diameter, ovalness and straightness after installation.

~~(e)~~ (g) Intermediate shaft bearings' loads are not to exceed 80 per cent of the bearing manufacturer's allowed maximum load for plain journal bearings, based on the bearing projected area.

~~(f)~~ (h) ~~Main gear wheel~~ Equipment manufacturer's bearing loads are to be within the ~~gearbox~~ manufacturer's specified limits, i.e. prime movers, gearing.

~~(g)~~ (j) Resulting shear forces and bending moments are to meet the equipment manufacturer's specified coupling conditions~~ throughout the shafting system~~.

~~(h)~~ (k) The manufacturer's radial, axial and angular alignment limits for the flexible couplings are to be maintained.

2.4 Measurements

2.4.1 The system bearing load measurements are to be carried out to verify that the design loads have been achieved. In general the measurements will be carried out by the jack-up measurement technique using calibrated equipment.

2.4.2 For the first vessel of a new design an agreed programme of static shaft alignment measurements is to be carried out in order to verify that the shafting has been installed in accordance with the design assumptions and to verify the design assumptions in respect of the hull deflections and the effects of machinery temperature changes. The programme is to include static bearing load measurements in a number of selected conditions. Depending on the ship type and the operational loading conditions that are achievable prior to and during sea trials these should include, where practicable, combinations of light ballast cold, full ballast cold, full ballast hot and full draught hot with aft peak tank empty and full.

2.4.3 For vessels of an existing design or similar to an existing design where evidence of satisfactory service experience is submitted for consideration and for subsequent ships in a series a reduced set of measurements may be accepted. In such cases the minimum set of measurements is to be sufficient to verify that the shafting has been installed in accordance with the design assumptions and are to include at least one cold and one hot representative condition.

~~*2.4.1*~~ *2.4.4* Where calculations indicate that the system is sensitive to changes in alignment under different service conditions, the ~~optimized~~ shaft alignment is to be verified by measurements during sea trials using an approved strain gauge technique.

Volume 2, Part 6, Chapter 1

Steering Gear

Effective date 1 January 2007

■ *Section 7* Electrical power circuits and equipment

7.1 Electric power circuits, electric control circuits, monitoring and alarms

7.1.2 The alarms required by 7.1.1 are to be provided on the bridge and in the main machinery space or control room from which the main machinery is normally controlled.

~~*7.1.2*~~ *7.1.3* Indicators for running indication of each main and auxiliary motor are to be installed on the navigating bridge and at a suitable main machinery control position.

7.1.4 A low-level alarm is to be provided for each power actuating system hydraulic fluid reservoir to give the earliest practicable indication of hydraulic fluid leakage. Alarms are to be given on the navigation bridge and in the machinery space where they can be readily observed.

Existing paragraphs 7.1.3 *to* 7.1.8 *have been renumbered* 7.1.5 *to* 7.1.10.

■ *Section 8*
Monitoring and alarms

8.1 Monitoring

Table 1.8.1 Alarms

Item	Alarm	Note
Angular position of the Steering Mechanism	—	Indication, *see* 8.1.2
Steering power units, power	Failure	—
Steering motors	Overload ~~single~~ Single phase	~~Also~~ For alarm and running indication ~~on bridge and machinery control station~~, locations, *see* 7.1.2 and 7.1.3
Control system power	Failure	—
Steering gear hydraulic oil ~~tank~~ level	Low	Each ~~tank~~ reservoir to be monitored. For alarm locations, *see* 7.1
Auto pilot	Failure	Running indication
Hydraulic oil temperature	High	Where oil cooler is fitted
Hydraulic lock	Fault	Where more than one system (either power or control) can be operated simultaneously each ~~each~~ system is to be monitored, ~~(~~*see* Note 1~~)~~
Hydraulic oil filter differential pressure	High	When oil filters are fitted

NOTE
1. This alarm is to identify the system at fault and to be activated when (for example):
    - Position of the variable displacement pump control system does not correspond with given order; or
    - incorrect position of 3-way full flow valve or similar in constant delivery pump system is detected.

8.1.3 The alarms described in Table 1.8.1 are to be indicated on the navigating bridge and the additional locations described and are to be in accordance with the alarm system specified by Pt 9, Ch 1.

Volume 2, Part 7, Chapter 1

Piping Design Requirements

Effective date 1 January 2007

■ *Section 1*
Scope

1.1 Application

1.1.1 This Chapter applies to all naval ships intended to be classed and covers the design and construction of ~~essential~~ piping systems, including components and fittings forming part of such systems.

■ *Section 2*
General

2.3 Classes of piping systems and components

Fig. 1.2.1 ~~Pressure/Temperature limits for~~ Classes of piping system

■ *Section 5*
Pipe connections

5.10 Mechanical connections for piping

(*Part only shown*)

Table 1.5.3 Application of mechanical joints

Systems	Kind of connections		
	Pipe unions	Compression Couplings (6)	Slip-on Joints
Flammable fluids (Flash point <60° C)			
~~Cargo oil lines~~ Aircraft and vehicle oil fuel lines	+	+	+5
~~Crude oil washing lines~~	~~+~~	~~+~~	~~+5~~
Vent lines	+	+	+3
~~**Inert gas**~~			
~~Water seal effluent lines~~	~~+~~	~~+~~	~~+~~
~~Scrubber effluent lines~~	~~+~~	~~+~~	~~+~~
~~Main lines~~	~~+~~	~~+~~	~~+2,5~~
~~Distributions lines~~	~~+~~	~~+~~	~~+5~~
Flammable fluids (Flash point > 60° C)			
~~Cargo oil lines~~ Aircraft and vehicle oil fuel lines	+	+	+5
~~Fuel oil lines~~ Ship's machinery oil fuel line	+	+	+2,3
Lubricating oil lines	+	+	+2,3
Hydraulic oil	+	+	+2,3
Thermal oil	+	+	+2,3

■ *Section 13*
Flexible hoses

13.1 General

~~*13.1.1* Short joining lengths of flexible hoses of approved type may be used, where necessary to accommodate relative movement between various items of machinery connected to permanent piping systems.~~

13.1.1 A flexible hose assembly is a short length of metallic or non-metallic hose normally with prefabricated end fittings ready for installation.

13.1.2 For the purpose of approval for the applications in 13.2, details of the materials and construction of the hoses, and the method of attaching the end fittings together with evidence of satisfactory prototype testing, are to be submitted for consideration. The materials used in the construction of flexible hoses are to be suitable for the intended purposes.

~~*13.1.3* In general, the use of hose clips as a means of securing the ends of hoses is to be restricted to the engine cooling water system, where the hose consists of a short, straight length joining two metal pipes, between two fixed points on the engine.~~

~~*13.1.4* Prototype pressure tests are to be carried out on each new type of hose, complete with end fittings, and in no case is the bursting pressure to be less than five times the maximum working pressure in service.~~

~~*13.1.5* In machinery spaces and other locations where sources of ignition are present, flexible hoses intended for use in systems containing flammable liquids are to be of approved fire resisting materials in compliance with an acceptable standard. Hoses complete with the attachments are to be type tested to verify fire resistance.~~

13.1.3 Hose clamps and similar types of end attachments are not be used for flexible hoses in piping systems for steam, flammable media, starting air systems or for sea-water systems where failure may result in flooding. In other piping systems, the use of hose clamps may be accepted where the working pressure is less than 5 bar and provided that there are two clamps at each end connection.

13.1.4 Flexible hoses are to be limited to a length necessary to provide for relative movement between fixed and flexibly mounted items of machinery/equipment or systems.

13.1.5 Flexible hoses are not to be used to compensate for misalignment between sections of piping.

13.1.6 Flexible hose assemblies are not to be installed where they may be subjected to torsional deformation (twisting) under normal operating conditions.

13.1.7 The number of flexible hoses in piping systems mentioned in this section is to be kept to a minimum and to be limited for the purpose stated in 13.2.1.

13.1.8 Where flexible hoses are intended for use in piping systems conveying flammable fluids, they are not to be installed in close proximity to hot surfaces, electrical installations or other sources of ignition. The risk of ignition due to failure of the hose assembly and subsequent release of fluids is to be mitigated as far as practicable by the use of screens or other suitable protection.

13.1.9 Flexible hoses are to be installed in clearly visible and readily accessible locations.

13.1.10 The installation of flexible hose assemblies is to be in accordance with the manufacturer's instructions and use limitations with particular attention to the following:
(a) Orientation.
(b) End connection support (where necessary).
(c) Avoidance of hose contact that could cause rubbing and abrasion.
(d) Minimum bend radii.

13.1.11 Flexible hoses are to be permanently marked by the manufacturer with the following details:
(a) Hose manufacturer's name or trademark.
(b) Date of manufacture (month/year).
(c) Designation type reference.
(d) Nominal diameter.
(e) Pressure rating.
(f) Temperature rating.
Where a flexible hose assembly is made up of items from different manufacturers, the components are to be clearly identified and traceable to evidence of prototype testing. *See* Pt 1, Ch 2,4.19 regarding requirements for a flexible hose register.

13.2 Applications

13.2.1 Short joining lengths of flexible hoses complying with the requirements of this Section may be used, where necessary, to accommodate relative movement between various items of machinery connected to permanent piping systems. The requirements of this Section may also be applied to temporarily-connected flexible hoses or hoses of portable equipment.

~~*13.2.1*~~ *13.2.2* ~~Synthetic rubber~~ Rubber or plastics hoses, with integral cotton or similar braid reinforcement, may be used in fresh and sea-water cooling systems. In the case of sea-water systems, where failure of the hoses could give rise to the danger of flooding, the hoses are to be suitably enclosed, as indicated in 14.2.4.

~~*13.2.2*~~ *13.2.3* ~~Synthetic rubber~~ Rubber or plastics hoses, with single or double closely woven integral wire braid or other suitable material reinforcement, or convoluted metal pipes with wire braid protection, may be used in bilge, ballast, compressed air, fresh water, sea-water, fuel oil, lubricating oil, Class III steam ~~and~~ hydraulic and thermal oil systems. Where ~~synthetic~~ rubber or plastics hoses are used for oil fuel supply to burners, the hoses are to have external wire braid protection in addition to the integral wire braid. Flexible hoses for use in steam systems are to be of metallic construction.

~~*13.2.3* Flexible hoses may also be used to accommodate the effects of shock where associated with defined military requirements. *See* Pt 1, Ch 2,4.8 and 4.10.~~

13.2.4 Flexible hoses are not to be used in high pressure fuel oil injection systems.

13.2.5 The requirements in this Section for flexible hose assemblies are not applicable to hoses intended to be used in fixed fire extinguishing systems.

13.2.6 Short lengths of flexible hoses may be used for acoustic attenuation where agreed by LR. The use of hoses for such applications is to be kept to a minimum.

13.3 Design requirements

13.3.1 Flexible hose assemblies are to be designed and constructed in accordance with recognised National or International standards acceptable to LR.

13.3.2 Flexible hoses are to be complete with approved end fittings in accordance with manufacturer's specification. End connections which do not have flanges are to comply with 5.2 as applicable and each type of hose/fitting combination is to be subject to prototype testing to the same standard as that required by the hose with particular reference to pressure and impulse tests.

13.3.3 Flexible hose assemblies intended for installation in piping systems where pressure pulses and/or high levels of vibration are expected to occur in service, are to be designed for the maximum expected impulse peak pressure and forces due to vibration. The tests required by 13.4 are to take into consideration the maximum anticipated in-service pressures, vibration frequencies and forces due to installation.

13.3.4 Flexible hose assemblies constructed of non-metallic materials intended for installation in piping systems for flammable media, and sea-water systems where failure may result in flooding, are to be of fire-resistant type. Fire resistance is to be demonstrated by testing to ISO 15540 and ISO 15541.

13.3.5 Flexible hose assemblies are to be suitable for the intended location and application, taking into consideration ambient conditions, compatibility with fluids under working pressure and temperature conditions consistent with the manufacturer's instructions and any other applicable requirements in the Rules.

13.4 Testing

13.4.1 Acceptance of flexible hose assemblies is subject to satisfactory prototype testing of a representative hose assembly. Prototype test programmes for flexible hose assemblies are to be submitted by the manufacturer and are to be sufficiently detailed to demonstrate performance in accordance with the specified standards.

13.4.2 For a particular hose type complete with end fittings, the tests, as applicable, are to be carried out on different nominal diameters for pressure, burst, impulse and fire resistance in accordance with the requirements of the relevant standard. The following standards are to be used as applicable:

- ISO 6802 – *Rubber and plastics hoses and hose assemblies – Hydraulic pressure impulse test without flexing*.
- ISO 6803 – *Rubber and plastics hoses and hose assemblies – Hydraulic pressure impulse test with flexing*.
- ISO 15540 – *Ships and marine technology – Fire resistance of hose assemblies – Test methods*.
- ISO 15541 – *Ships and marine technology – Fire resistance of hose assemblies – Requirements for test bench*.
- ISO 10380 – *Pipework – Corrugated metal hoses and hose assemblies*.

Other standards may be accepted where agreed by LR.

13.4.3 All flexible hose assemblies are to be satisfactorily prototype burst tested to an international standard* to demonstrate they are able to withstand a pressure of not less than four times the design pressure without indication of failure or leakage.

NOTE:
The international standards, e.g. EN or SAE for burst testing of non-metallic hoses, require the pressure to be increased until burst without any holding period at 4 x Maximum Working Pressure.

Volume 2, Part 7, Chapter 2

Ship Piping Systems

Effective date 1 January 2007

■ *Section 10*

Air, overflow and sounding pipes

10.4 Termination of air pipes

10.4.2 Air pipes from storage tanks containing lubricating or hydraulic oil may terminate in the machinery space, provided that the open ends are so situated that issuing oil cannot come into contact with electrical equipment or heated surfaces. Air pipes from heated lubricating oil tanks are to be led to a safe position on open deck.

Volume 2, Part 7, Chapter 3

Machinery Piping Systems

CORRIGENDUM

■ *Section 2*

Oil fuel – General requirements

2.3 Oil fuel sampling

2.3.3 The sampling arrangements within the machinery space are to be capable of safely providing samples when machinery is running and are to be provided with isolating valves and cocks of the self-closing type. The sampling points are to be located in positions as far removed as possible from any heated surface or electrical equipment such as to preclude impingement of oil fuel onto such surfaces on equipment under all operating conditions, *see* Vol 2, Pt 1, ~~Ch 2,4.5~~ Ch 2,4.6.

Effective date 1 January 2007

2.10 Oil fuel contamination

2.10.1 The materials and/or their surface treatment used for the storage and distribution of oil fuel are to be selected such that they do not introduce contamination or modify the properties of the fuel. The use of copper or zinc compounds in oil fuel piping systems where they may come into contact with the fuel is not permitted except for small diameter pipes in low pressure systems, *see* 4.6.1.

■ *Section 3*

Oil fuel burning arrangements

3.10 Oil fuel treatment for supply to diesel engines and gas turbines

3.10.3 ~~Centrifuges~~ Where centrifuges are used for oil fuel treatment they are to be type tested ~~for their intended usage when installed on board a ship~~ in accordance with a standard acceptable to LR and are to be installed on board in accordance with the manufacturer's recommendations. The fuel grades, flow rates and any heating arrangements on board are to be consistent with the specification for type tested centrifuge.

■ *Section 8*

Lubricating oil systems

8.1 General requirements

8.1.1 In addition to the requirements detailed in this Section, the requirements of Sections 2 and 4 are to be complied with in so far as they are applicable. In all cases ~~2.8.1 to 2.8.4~~ 2.9.1 to 2.9.3 and 4,2, 4.3, 4.5, 4.8, 4.11 and 4.16 are to apply.

CORRIGENDUM

8.5 Maintenance of bearing lubrication

8.5.1 The arrangements for lubricating bearings and for draining crankcase and other oil sumps of main and auxiliary engines, gearcases, electric generators, motors, and other running machinery are to be so designed that lubrication will remain efficient with the ship inclined under the conditions as shown in Pt 1, ~~Ch 2,4.5~~ Ch 2,4.6.

Volume 2, Part 7, Chapter 4

Aircraft/Helicopter/Vehicle Fuel Piping and Arrangements

CORRIGENDUM

■ *Section 2*
Refuelling facilities

2.2 Fuel pumping and filling

2.2.12 Fuelling and defuelling stations are to be located away from, or sheltered from, radar and HF radio hazards. *See also* Pt 1, ~~Ch 2,4.18~~ Ch 2,4.19.

Effective date 1 January 2007

■ *Section 3*
Pump rooms

3.1 General

3.1.4 Alarms and safety arrangements are to be provided as indicated in 3.1.5 and Table 4.3.1. These requirements are applicable to pump rooms where pumps for fuels, such as fuel pumps and stripping pumps are provided and not for pump rooms intended solely for ballast transfer.

3.1.5 A system for continuously monitoring the concentrations of hydrocarbon gases within the pump room is to be fitted. Monitoring points are to be located in positions where potentially dangerous concentrations may be readily detected. Gas analysing units with non-safe-type measuring equipment may be located outside ~~cargo~~ dangerous areas (e.g. in ~~cargo~~ oil fuel pumping control room, navigation bridge or engine room when mounted on the ~~forward~~ adjacent bulkhead) provided that:

(a) sampling lines do not pass through gas safe spaces, except where permitted by (e);
(b) the gas sampling pipes are fitted with flame arresters. Sample gas is to be led to the atmosphere with outlets arranged in a safe location, in the open atmosphere;
(c) bulkhead penetrations of sample pipes between safe and dangerous areas are of an approved type. A manual isolating valve is to be fitted in each of the sampling lines at the bulkhead in the safe area;
(d) the gas detection equipment including sampling piping, sampling pumps, solenoid valves and analysing units, are located in a fully enclosed steel cabinet, with a gasketed door, monitored by its own sampling point. At gas concentrations above 30 per cent LEL inside the steel cabinet, the entire gas-analysing unit is to be automatically shutdown; and
(e) where the cabinet cannot be arranged on the bulkhead, sample pipes are to be of steel or other equivalent material and without detachable connections, except for the connection points for isolating valves at the bulkhead and analysing units. The sample pipes are to be led by their shortest route.

Sequential sampling is acceptable as long as it is dedicated for the pump room only, including exhaust ducts, and the detection equipment is capable of monitoring from each sampling head location at intervals not exceeding 30 minutes.

Volume 2, Part 7, Chapter 5

Ship Type Piping Systems

CORRIGENDUM

■ *Section 3* System arrangements

3.1 Piping systems

3.1.14 Piping system arrangements and associated equipment are to be capable of operating satisfactorily under the conditions shown in ~~Table 2.4.1~~ Table 2.4.2 in Pt 1, Ch 2.

Volume 2, Part 9, Chapter 1

Control Engineering Systems

CORRIGENDA

■ *Section 1* General engineering systems

1.2 Plans and information

1.2.5 **Programmable electronic systems.** (In addition to the documentation required by 1.2.2.)

- System requirements specification.
- Details of the hardware configuration in the form of a system block diagram, including input/output schedules.
- Hardware certification details, *see* ~~2.9.4~~ 2.9.5 and 2.11.3.
- Software quality plans, including applicable procedures, *see* 2.9.21.
- Factory acceptance, integration, harbour and sea trial test schedules for hardware and software.
- System integration plan, *see* 2.12.2.

1.3 Control, alarm and safety equipment

1.3.4 Assessment of performance parameters, such as accuracy, repeatability, etc., are to be in accordance with an acceptable specialised naval standard, national or international standard, e.g. ~~International Electrotechnical Commission, Publication 51 Recommendations for indicating electrical measuring instruments and their accessories.~~ IEC 60051, *Direct acting indicating analogue electrical measuring instruments and their accessories*.

Effective date 1 January 2007

■ *Section 2* Essential features for control, alarm and safety systems

2.1 General

2.1.1 ~~The essential features contained in 2.2 to 2.8 are to be incorporated in the design and installation of systems providing control, alarm or safety functions.~~ Where it is proposed to install control, alarm and safety systems to the equipment listed in 1.2.2 the applicable features contained in this Section are to be incorporated in the system design.

2.1.2 Systems complying with ISO 17894, *Ships and marine technology – Computer applications – General principles for the development and use of programmable electronic systems in marine applications*, may be accepted as meeting the requirements of this Section in which case evidence of compliance is to be submitted for consideration.

2.8 Fire detection alarm systems

2.8.7 Fire detection control units (including addressable systems), indicating panels, detector heads, manual call points and short circuit isolation units are to be Type Approved in accordance with Test Specification Number 1 given in LR's Type Approval System for an environmental category appropriate for the locations in which they are intended to operate. For addressable systems, *see also* 2.9.

2.9 Programmable electronic systems – General requirements

2.9.1 The requirements of ~~2.9.2 to 2.9.21~~ this sub-Section are to be complied with where control, alarm or safety systems incorporate programmable electronic equipment. ~~For~~ Systems for essential services and safety critical applications, systems~~,~~ incorporating shared data communication links and systems which are integrated are to comply with the additional requirements of 2.11, 2.12, and 2.13 ~~also apply~~ as applicable. For systems complying with ISO 17894, *Ships and marine technology – Computer applications – General principles for the development and use of programmable electronic systems in marine applications*, *see* 2.1.2.

2.9.2 Where programmable electronic systems share resources, any components that can affect the ability to effectively provide required control, alarm or safety functions are to fulfil the requirements of 2.9 to 2.12 related to providing those required functions.

~~2.9.2~~ 2.9.3 Programmable electronic equipment is to revert to a defined safe state on initial start up or re-start in the event of failure.

~~2.9.3~~ 2.9.4 In the event of failure of any programmable electronic equipment, the system, and any other system to which it is connected, is to fail to a defined safe state or maintain safe operation, as applicable.

~~2.9.4~~ 2.9.5 Programmable electronic equipment is to be certified by a recognised authority as suitable for the environmental conditions in which it is intended to operate, *see also* 2.11.3.

~~*2.9.5* Where programmable electronic equipment shares resources, e.g. a data communication link, with any control, alarm or safety system for essential services or safety critical system, software is to meet the requirements of 2.11.7.~~

2.9.7 Programmable electronic equipment is to be provided with self-monitoring capabilities such that hardware and functional failures will initiate an audible and visual alarm in accordance with the requirements of 2.3 and, where applicable, 4.2. Hardware failure indications are to enable faults to be isolated at least down to the level of the lowest replaceable unit and the self-monitoring capabilities are to ensure that diagnostic information is readily available.

2.9.16 Display units are to comply with the requirements of International Electrotechnical Commission Standard IEC ~~950~~ 60950:1991, *Safety of information technology equipment, including electrical business equipment, in respect of emission of ionising radiation*.

2.10 Data communication links

2.10.2 Data communication is to be automatically restored within 45 seconds in the event of a single component failure. Upon restoration, priority is to be given to updating safety critical data and control, alarm and safety related data for essential services. Components comprise all items required to facilitate data communication, including cables, switches, repeaters, software components and power supplies.

2.11 Programmable electronic systems – Additional requirements for Mobility category and safety critical systems

2.11.3 Items of programmable electronic equipment used to implement control, alarm and safety functions are to be certified in accordance with LR's Type Approval System, *Test Specification Number 1 (2002)*.

2.12 Programmable electronic systems – Additional requirements for integrated systems

2.12.2 System integration is to be managed by a single designated party, and is to be carried out in accordance with a defined procedure identifying the roles, responsibilities and requirements for all ~~involved~~ parties involved. This procedure is to be submitted for consideration where the integration involves control functions for Mobility category systems or safety critical functions.

2.12.4 ~~In the event of failure of any part of the integrated system, only those functions that depend on the failed part are to be affected.~~ Reversionary modes of operation are to be provided to ensure safe and graceful degradation in the event of one or more failures. In general, the integrated system is to be arranged such that the failure of one part will not affect the functionality of other parts, except those that require data from the failed part.

■ *Section 3*

Unattended machinery space(s) – UMS notation

3.7 Supply of electric power, general

3.7.1 For naval ships operating with one generator set in service, arrangements are to be such that a standby generator will automatically start and connect to the switchboard in as short a time as practicable, but in any case within 45 seconds, on loss of the service generator. For naval ships operating with two or more generator sets in service, arrangements are to be such that on loss of one generator the remaining one(s) are to be adequate for continuity of essential services. For the detailed requirements of these arrangements, *see* Pt 10, Ch 1,2.2.

Volume 2, Part 10, Chapter 1

Electrical Engineering

CORRIGENDUM

■ *Section 1*
General requirements

1.1 Application

1.1.7 Reference is to be made to Pt 1, ~~Ch 2,4.8~~ Ch 2,4.9 concerning military requirements where these interface with the provisions of classification.

Effective date 1 January 2007

1.2 Plans

1.2.1 At least three copies of the plans and particulars in 1.2.2 to ~~1.2.12~~ 1.2.14 are to be submitted for consideration. Single copies only are required of plans in ~~1.2.13 to 1.2.18~~ 1.2.15 to 1.2.20. Additional copies are to be submitted when requested.

1.2.10 Documented test procedures to demonstrate compliance with STANAG 1008, or a relevant and acceptable naval standard, where the electrical class notation **ELS** is required.

1.2.12 A schedule of batteries fitted for use for emergency and essential services, giving details of:
- type and manufacturer's type designation;
- voltage and ampere-hour rating;
- location;
- equipment and/or system(s) served;
- maintenance/replacement cycle dates;
- date(s) of maintenance and/or replacement; and
- for replacement batteries in storage, the date of manufacture and shelf life; with accompanying battery replacement procedure documentation to show compliance with 11.8.

~~*1.2.12*~~ *1.2.13* Plans of propulsion generators, motors, converting equipment, reactors and filters. ~~In addition for all cables which pass through atriums or equivalent spaces and for vertical runs in trunks or other restricted spaces, information to show compliance with 10.8.8.~~

1.2.14 For all cables that pass through atria or equivalent spaces, and for vertical runs in trunks or other restricted spaces, the information supplied is to show compliance with 10.8.8.

Existing paragraphs 1.2.13 *to* 1.2.18 *have been renumbered* 1.2.15 *to* 1.2.20.

1.4 Additions or alterations

1.4.4 When it is proposed to replace permanently installed secondary valve-regulated sealed batteries with vented batteries, details are to be submitted for consideration to ensure continued safety in the presence of the products of electrolysis and evaporation being allowed to escape freely from the cells to the atmosphere. These details are to demonstrate that there will be adequate ventilation in accordance with 11.5.9 and that the location and installation requirements of 11.3 and 11.4 are complied with.

1.7 Quality of power supplies

1.7.2 Unless specified otherwise, a.c. electrical equipment is to operate satisfactorily with the following simultaneous variations, from their nominal value, when measured at the consumer input terminals.

(a) voltage:
permanent variations +6%, –10%
transient variations due to step changes in load ~~+20%, –15%~~ ±20%
recovery time 1,5 seconds

(b) frequency:
permanent variations ±5%
transient variations due to step changes in load ±10%
recovery time 5 seconds
A maximum rate of change of frequency not exceeding ±1,5 Hz per second during cyclic frequency fluctuations.

1.7.5 Where the electrical class notation **ELS** is to be assigned, the quality of electrical supplies is to comply with STANAG 1008, or a relevant and acceptable naval standard. Reference is to be made to 1.8.

1.8 Quality of power supplies – ELS notation

1.8.1 ~~Where the quality and arrangements of the generation and distribution power supplies meet an accepted and relevant national or international defined standard, such as STANAG 1008, suitable to supply sensitive military loads in both weapons and control systems (including pulsed and other special requirements) the class notation **ELS** may be assigned. The electrical system is to be stable under foreseen operational conditions when supplying these and other normal seagoing loads.~~ Where electrical power, suitable for supplying sensitive military loads, is provided in accordance with the applicable provisions of a relevant and acceptable naval standard, such as STANAG 1008, the class notation **ELS** may be assigned.

1.8.2 The electrical system is to be stable under foreseen operational conditions when supplying both the sensitive military loads and other normal seagoing loads.

~~*1.8.2*~~ *1.8.3* The quality of the ~~main generation and distribution~~ power supplies to the sensitive military loads ~~are~~ is to comply with the ~~defined~~ standard, in place of the limits specified by 1.7.2 and 1.7.3.

~~1.8.3~~ 1.8.4 ~~The~~ Where the main generation and the distribution power supplies are also required to comply with the standard, ~~to~~ the ~~sensitive military loads are~~ main generation and distribution system is to be of an insulated type in compliance with 5.4. *See also* 5.5.7.

Existing paragraphs 1.8.4 *to* 1.8.6 *have been renumbered* 1.8.5 *to* 1.8.7.

1.9 Ambient reference and operating conditions

CORRIGENDUM

1.9.1 The rating for classification purposes of essential electrical equipment intended for installation in ships to be classed for unrestricted (geographical) service is to be based on an engine room ambient temperature of 45ºC, and a seawater temperature at the inlet of 32ºC. The equipment manufacturer is not expected to provide simulated ambient reference conditions at a test bed. The requirement excludes military aspects that are required to be defined by Pt 1, ~~Ch 2,4.8~~ Ch 2,4.9.

Effective date 1 January 2007

1.9.3 Main and essential auxiliary machinery and equipment is to operate satisfactorily under the conditions shown in Pt 1, Ch 2,4.5.

NOTE

Details of local environmental conditions are stated in Annex B of IEC 60092: *Electrical installations in ships – Part 101: Definitions and general requirements*.

1.9.4 Where electrical equipment is installed within environmentally controlled spaces the ambient temperature for which the equipment is suitable for operation at its rated capacity may be reduced to a value not less than 35°C provided:

- the equipment is not for use for emergency services and is located outside of machinery space(s);
- temperature control is achieved by at least two cooling units so arranged that in the event of loss of one cooling unit, for any reason, the remaining unit(s) is capable of satisfactorily maintaining the design temperature;
- the equipment is able to be initially set to work safety within a 45°C ambient temperature until such a time that the lesser ambient temperature may be achieved; the cooling equipment is to be rated for a 45°C ambient temperature;
- alarms are provided, at a continually attended control station, to indicate any malfunction of the cooling units.

See also Pt 9, Ch 1,1.3.3.

1.9.5 Where equipment is to comply with 1.9.4, it is to be ensured that electrical cables for their entire length are adequately rated for the maximum ambient temperature to which they are exposed along their length.

1.9.6 Equipment used for cooling and maintaining the lesser ambient temperature in accordance with 1.9.4 are considered essential services and are to satisfy the requirements of 5.2.

CORRIGENDA

1.10 Inclination of ship

1.10.1 Emergency and essential electrical equipment is to operate satisfactorily under the conditions as shown in ~~Table 2.4.1~~ Table 2.4.2 in Pt 1, Ch 2,4.5.

1.11 Location and construction

(*Part only shown*)

1.11.4 Equipment design and the choice of materials are to reduce the likelihood of fire, ensuring that:

NOTE

Compliance with IEC ~~Publication~~ 60695; Fire hazard testing, or an alternative and acceptable standard, will satisfy this requirement, *see also* 1.14.4.

1.11.8 The operation of all electrical equipment and the lubrication arrangements are to be efficient under such conditions of vibration and shock as arise in normal practice. This requirement excludes military aspects that are required to be defined by Pt 1, ~~Ch 2,4.8~~ Ch 2,4.9.

1.11.11 Where electrical power is used for propulsion, the equipment is to be so arranged that it will operate satisfactorily in the event of partial flooding by bilge water above the tank top up to the bottom floor plate level under the normal angles of inclination given in 1.9 for essential electrical equipment, *see* Pt 7, Ch 2,4. This requirement excludes military aspects that are required to be defined by Pt 1, ~~Ch 2,4.8~~ Ch 2,4.9.

Effective date 1 January 2007

■ *Section 2*

Main source of electrical power

2.5 Main propulsion driven generators not forming part of the main source of electrical power

2.5.1 Generators and generator systems, having the ship's propulsion machinery as their prime mover but not forming part of the ship's main source of electrical power may be used whilst the ship is at sea to supply electrical services required for normal operational and habitable conditions provided that the requirements of 2.5.2 to 2.5.4 are satisfied.

2.5.2 Within the declared operating range of the generators and/or generator system, the specified voltage and frequency variations of the Rules are to be met.

2.5.3 Where there is remote control of the propulsion machinery, arrangements are to ensure that essential machinery power supplies are maintained during manoeuvring conditions in order to prevent a blackout situation.

2.5.4 In addition to the requirements of 2.2.3, arrangements are to be fitted to automatically start and connect one of the generators forming the main source of power should the frequency variations exceed those permitted by the Rules.

CORRIGENDA

Section 3
Emergency and alternative sources of electrical power

3.2 Emergency source of electrical power

3.2.12 In order to ensure ready availability of the emergency source of electrical power, and to ensure its continued safe operation, arrangements are to be made, where necessary, to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that electrical power will be available automatically to the emergency circuits.

Section 5
Supply and distribution

5.1 Systems of supply and distribution

(*Part only shown*)
5.1.1 The following systems of generation and distribution are acceptable:

NOTE:
Where the **ELS** notation is to be assigned, earthed systems are permitted only when the additional requirements of 5.5.7 are satisfied. *See also* ~~1.8.3~~ 1.8.4.

5.5 Earthed distribution systems

5.5.7 Where the **ELS** notation is to be assigned, earthed systems are not permitted unless they are isolated from the main generation and distribution system, e.g. through transformers and/or motor generator sets. *See also* ~~1.8.3~~ 1.8.4.

Section 8
Rotating machines

8.1 General requirements

8.1.1 Rotating machines are to comply with the relevant part of IEC 60092, or an acceptable and relevant National Standard, and the requirements of this Section. In addition, military aspects for shock are to be defined as required by Pt 1, ~~Ch 2,4.8~~ Ch 2,4.9.

8.4 Generator control

8.4.8 For **ELS** notation, *see* ~~1.8.5~~ 1.8.6.

Section 10
Electric cables and busbar trunking systems (busways)

10.1 General

(*Part only shown*)

Table 1.10.1 Electric cables

Application	IEC ~~Publication~~ Standard	Title

Effective date 1 January 2007

Section 11
Batteries

11.8 Recording of batteries for emergency and essential services

11.8.1 A schedule of batteries fitted for use for essential and emergency services is to be compiled and maintained.

11.8.2 Procedures are to be put in place and documented to ensure that, where batteries are replaced, they are of an equivalent performance type, *see also* 1.4.4.

11.8.3 When additions or alterations are proposed to the existing batteries for essential and emergency services, the schedule and replacement procedure documentation are to be updated to reflect the proposed installation and submitted in accordance with 1.4.2.

11.8.4 The schedule and replacement procedure documentation are to be made available to the LR Surveyor on request.

Section 13
Electrical equipment for the use in explosive gas atmospheres or in the presence of combustible dusts

13.6 Ventilation

13.6.3 An alarm is to be provided on the navigating bridge and the engine control room to indicate any loss of the required ventilation capacity. Initiation of an alarm by a fan motor running or fan rotation monitoring device will not normally satisfy this requirement.

CORRIGENDA

■ *Section 17*

Crew and embarked personnel emergency safety systems

17.4 Escape route or low location lighting (LLL)

17.4.3 The power supply arrangements to the LLL are to be arranged so that a single fault or a fire in any one fire zone or deck does not result in loss of the lighting in any other zone or deck. This requirement may be satisfied by the power supply circuit configuration, use of fire-resistant cables complying with 10.5.3, and/or the provision of suitably located power supply units having integral batteries adequately rated to supply the connected LLL for a minimum period of 60 minutes~~, *see* 11.3.7~~.

■ *Section 20*

Testing and trials

20.2 Trials

20.2.5 Unless it has been satisfactorily shown by the design verification and validation process required by ~~1.8.4~~ 1.8.5, that the power supply quality complies with the requirements of the defined standard, then compliance is to be demonstrated by measurements taken at the switchboards/ section-boards used to supply sensitive military loads (*see* 1.8.1).

Volume 2, Part 11, Chapter 1

Made and Fresh Water Systems

CORRIGENDA

■ *Section 3*

System arrangements

3.3 Piping system design

3.3.11 Piping system arrangements and associated equipment are to be capable of operating satisfactorily under the conditions shown in ~~Table 2.4.1~~ Table 2.4.2 in Pt 1, Ch 2.

■ *Section 5*

Testing and trials

5.2 Type testing

5.2.1 Evidence that the required performance of made water and pumping equipment is capable of being maintained under ambient and inclination operating conditions defined in Pt 1, Ch 2,4.4 and ~~4.5~~ 4.6 is to be provided by the manufacturer.

Volume 2, Part 11, Chapter 2

Heading, Ventilation and Cooling Arrangements

CORRIGENDA

Section 1

General requirements

1.2 Scope

1.2.4 Pump room ventilation systems are to comply with Pt 7, ~~Ch 5,3~~ Ch 4,3 as applicable.

1.2.6 NBC Protection guidance for ventilation is contained in Pt 1, ~~Ch 2,4.11~~ Ch 2,4.12.

Section 2

Construction and installation

2.6 Filtration units for air intakes

2.6.3 Filtration units for NBC Protection are to be in accordance with the guidance in Pt 1, ~~Ch 2,4.11~~ Ch 2,4.12 as applicable.

Section 3

System arrangements

3.1 General

(*Part only shown*)

3.1.2 The design and capability of supply and exhaust systems for ventilation purposes are to address the following requirements as applicable:

(g) In the case of vessels designed for NBC Protection, the system is to be designed to maintain the vessel at an overpressure relative to the outside ambient pressure. The system is also to provide a breathable atmosphere, minimising CO_2 levels with the maximum ship's complement. Odour filtration is to be provided for all those areas that are likely to produce foul smells and are subject to recirculation in closedown, e.g. bathrooms, toilets, galleys. *See* Pt 1, ~~Ch 2,4.11~~ Ch 2,4.12 for NBC Protection guidance.

Section 5

Testing and trials

5.2 Type testing

5.2.1 Evidence that the required performance of heating/cooling/filtration systems, pump and fan equipment is capable of being maintained under ambient and inclination operating conditions defined in Pt 1, Ch 2,4.4 and ~~4.5~~ 4.6 is to be provided by the manufacturer.

Volume 2, Part 11, Chapter 3

Waste Systems

CORRIGENDUM

Section 6

Testing and trials

6.2 Type testing

6.2.1 Evidence that the required performance of drainage and pumping equipment is capable of being maintained under ambient and inclination operating conditions defined in Pt 1, Ch 2,4.4 and ~~4.5~~ 4.6 is to be provided by the manufacturer.

Volume 3, Part 1, Chapter 1

Ice Navigation – First Year Ice Conditions

Effective date 1 January 2007

■ *Section 3*

Machinery and engineering systems

3.5 Materials for propellers

3.5.3 Spheroidal cast iron load transmitting-components of controllable-pitch mechanisms are to be manufactured, tested and certified in accordance with the requirements of Table 7.3.2 in Ch 7,3 of the Rules for Materials.

Volume 3, Part 1, Chapter 5

Propulsion and Steering Machinery Redundancy

Effective date 1 January 2007

■ *Section 1*

General requirements

1.1 General

1.1.2 The requirements, which are optional, cover machinery arrangements and control systems necessary for ships which have propulsion and steering systems configured such that, in the event of a single failure of a system or item of equipment, the ship will retain the ability to use available ~~not less than 50 per cent of the~~ installed prime mover capacity and ~~not less than 50 per cent of the~~ installed propulsion systems that are unaffected by the failure. The ship is also to ~~and~~ retain steering capability at a service speed of not less than seven knots. ~~The requirements also cover machinery arrangements where the propulsion and steering systems are installed in separate compartments such that, in the event of a loss of one compartment, the ship will retain availability of propulsion power and manoeuvring capability.~~

1.1.3 The requirements also cover machinery arrangements where the propulsion and steering systems are installed in separate compartments such that, in the event of a loss of one compartment, the ship will retain availability of propulsion power and manoeuvring capability.

~~*1.1.3*~~ *1.1.4* Requirements additional to these Rules may be imposed by the Naval Authority.

~~*1.1.4*~~ *1.1.5* Sections 2, 3 and 4 state the applicable requirements for arrangements necessary to maintain availability of propulsion and manoeuvring capability, in the event of a single failure in equipment. Ships complying with the applicable requirements of Sections 2 to 4 of this Chapter will be eligible for the machinery class notation **PMR** or **PMRL** (Propulsion Machinery Redundancy), **SMR** or **SMRL** (Steering Machinery Redundancy) or **PSMR** or **PSMRL** (Propulsion and Steering Machinery Redundancy).

NOTE
The additional **L** character to **PMR**, **SMR** and **PSMR** notations indicates a limited capability.

~~*1.1.5*~~ *1.1.6* Section 5 states the additional requirements necessary to maintain availability of propulsion and manoeuvring capability where machinery is installed in separate compartments and the loss of any one compartment due to fire or flooding has been addressed. Ships complying with the applicable requirements of Sections 2 to 5 of this Chapter will be eligible for the machinery class notation **PMR★** or **PMRL★** (Propulsion Machinery Redundancy in separate machinery spaces), **SMR★** or **SMRL★** (Steering Machinery Redundancy in separate machinery spaces) or **PSMR★** or **PSMRL★** (Propulsion and Steering Machinery Redundancy in separate machinery spaces).

1.1.7 For assignment of **PSMR** or **PSMR★** machinery class notations, the ship is to retain the ability to use not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems and retain steering capability at a service speed of not less than seven knots in the event of a single failure of a system or item of equipment.

1.1.8 Where the ship does not comply with 1.1.7 but can retain a service speed of not less than seven knots using available installed prime mover capacity and propulsion systems (which may be less than 50 per cent) following a failure of a system or item of equipment, machinery class notations **PSMRL** or **PSMRL★** may be assigned. The available installed prime mover capacity and installed propulsion systems are to be identified and included in 1.2.7.

1.2 Plans and information

1.2.4 **Manoeuvring capability**. An assessment of the ship’s ahead and astern manoeuvring capability, under the following operating conditions, is to be submitted:

(a) Where ~~only~~ 50 per cent or less than ~~of~~ the installed prime mover capacity and ~~not less than~~ 50 per cent or less than ~~of~~ the installed propulsion systems is available.

(b) Where the steering capability requirements described in 3.2.1 are available.

IMO Resolution A.751(18) *Interim Standards for Ship Manoeuvrability,* provides guidance on standard manoeuvres required in an assessment of the manoeuvrability of ships.

1.2.7 **Installed prime mover capacity and installed propulsion systems**. A schedule of the propulsion systems and their operating capacity and capability under normal and foreseeable failure conditions is to be submitted.

Section 2

Failure Mode and Effects Analysis (FMEA)

2.1 General

2.1.7 The FMEA is to establish that in the event of a single component failure:

(a) For **PSMR** and **PSMR★** notations, that not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems is available, and that steering capability is retained at a speed of seven knots.

(b) For **PMR** and **PMR★** notations, that not less than 50 per cent of the installed prime mover capacity and not less than 50 per cent of the installed propulsion systems remain available.

(c) For **SMR** and **SMR★** notations, steering capability at a speed of seven knots is to be retained.

(d) For **PSMRL★** notation, that the ship will retain the ability to use available installed prime mover capacity and installed propulsion systems that are unaffected by the failure and retain steering capability at a service speed of not less than seven knots.

(e) For **PMRL★** notation, that the ship will retain the ability to use available installed prime mover capacity and installed propulsion systems that are unaffected by the failure.

Section 3

Machinery arrangements

3.1 Main propulsion machinery

3.1.2 For **PMRL**, **PSMRL**, **PMRL★** and **PSMRL★** notations, independent main propulsion systems are to be provided so that the ship will retain the ability to use the available installed prime mover capacity and installed propulsion systems following a single failure of a system or item of equipment. In the event of a single failure in equipment, the remaining system(s) is to be capable of maintaining a manoeuvring speed of not less than 7 knots and, for **PSMRL** and **PSMRL★** notations, give adequate manoeuvring capability, *see* 1.2.4.

3.3 Electrical power supply

3.3.2 In the event of the loss of one section or failure of the power supply from one generator, there is to be continuity of sufficient electrical power to supply essential services such that the available installed prime mover capacity and installed propulsion systems will continue to have the ability of functioning at its operational capability where **PSMRL**, **PSMRL★**, **PMRL** and **PMRL★** notations are required. *See* 3.2.1 for steering machinery requirements.

Existing paragraphs 3.3.2, 3.3.3 *and* 3.3.4 *have been renumbered* 3.3.3, 3.3.4 *and* 3.3.5.

Volume 3, Part 1, Chapter 7

Replenishment at Sea (RAS) Systems

Effective date 1 January 2007

■ *Section 1*
General requirements

1.1 Application

1.1.1 This Chapter states the requirements for Replenishment At Sea (RAS) systems installed in naval ships for the purpose of supplying and receiving solid or liquid supplies. The Chapter also states the requirements for Vertical Replenishment (VERTREP) and light jackstay RAS systems which may be used for transfer of personnel and light stores between naval ships. The requirements are in addition to the relevant requirements contained in Volumes 1 and 2 of these Rules. Other arrangements to supply solid and liquid stores by means of RAS will be specially considered.

1.2 RAS terminology

1.2.2 **RAS station**: The physical location of a combination of deck area and associated equipment that provides a ship with the capability to receive or deliver solids, liquid or personnel by means of passing RAS equipment between ships whilst underway. Note these Rules are only applicable to naval ships intended for supplying and receiving solid or liquid supplies and for personnel transfer.

1.2.4 **Abeam Replenishment**: The transfer of solid cargo, ~~or~~ personnel or liquid cargo by means of passing RAS equipment between ships while underway ~~and with~~ when the Receiving Ship will normally station-keep on ~~maintaining station abeam of~~ the Supplying Ship. Circumstances may exist when the Supplying Ship will be required to station-keep on the Receiving Ship.

1.2.6 **Vertical Replenishment (VERTREP)**: Transfer of solid cargo ~~and personnel~~ by underslung load from a helicopter and the winching of personnel where a ship is not provided with a flight deck.

■ *Section 4*
Design and construction

4.2 Functionality

4.2.1 In general, NS1 and NS2 type ships are to be configured such that replenishment of solids and liquids can be conducted concurrently. Ships are to be capable of supplying and receiving RAS equipment such that they can transfer personnel by abeam replenishment. For abeam RAS operations a minimum of four RAS stations (two port and two starboard) should be provided, (for larger ships six RAS stations may be incorporated). For astern RAS operations at least one station should be provided on the fo'c'sle for reception and on the aft deck for supply.

■ *Section 5*
Plans and particulars to be submitted

5.1 Plans and information

5.1.2 **Design statement**. A design statement of the RAS systems that details the capability and functionality under defined operating and emergency conditions. The design statement is to be agreed between the Designers and Owners/ Operators and is to include as applicable:

(a) Required class notations.
(b) Details of intended ~~supply~~ supplying and receiving ships.
(c) Description of each RAS operation and combination of equipment required.
(d) Plans showing each proposed combination of equipment, fully rigged.
(e) Details of solids that may be received or supplied (maximum size and weight together with UN hazard category if applicable) together with transfer rates.
(f) Details of liquids that may be received or supplied, (including flash point of oils and transfer rates).
(g) Details of the range of ship's speeds, sea and environmental conditions under which each RAS operation may be undertaken.
(h) Interoperability capability.
(j) Manning requirements.
(k) Details of arrangements for RAS operations in darkness.
(l) Details of hose clearing/drainage arrangements after RAS operations have been completed (*see* 9.1.4).

5.1.3 **Engineering and safety justification**. An engineering and safety justification for the RAS systems stating design standards used, ~~and~~ assumptions made and ~~providing~~ any technical evidence. The justification is to:

(a) State all design standards used for the design, manufacture, installation and testing of RAS systems and equipment.
(b) Provide details of all RAS equipment and compatibility of different items of equipment.
(c) Provide evidence that all RAS operations (equipment and combinations) at each RAS station as identified in the design statement, can be carried out safely and in accordance with classification and equipment manufacturer's requirements.
(d) Identify safe equipment configurations.
(e) Provide calculations that demonstrate that the structural loading is in accordance with Rule requirements.
(f) Provide calculations that demonstrate that equipment loads are in accordance with manufacturer's specified limits.
(g) Provide evidence that sufficient control, monitoring and communication facilities are provided to conduct RAS operations safely and efficiently.

(h) ~~Examine the dynamic behaviour (e.g. roll period, steering response, tendency to yaw, etc) of all the supplying ships identified to conduct RAS operations and draw up operational limits that define when RAS operations are not to be conducted between ships when this will result in possible dangerous hull interactions.~~ Limits are to be defined in terms of lateral separation between vessels, ship's speeds, wind force, sea conditions (wave height, ~~swell~~ period and direction) and environmental conditions (visibility). The validation of potential operational scenarios may be by using a set of generic ship types agreed between the Owner/Operator and the designer.

(j) Examine the effect of environmental conditions (e.g. sea state, water depth, visibility, wind strength, etc.) on the proposed RAS operations and define limiting conditions and define limiting environmental conditions for each RAS operation.

(k) Address the specific needs of emergency breakaway and demonstrate that such a procedure can be undertaken with all RAS equipment configurations at each RAS station. The recovery of equipment after an emergency breakaway is also to be addressed.

(l) Provide evidence that the ship internal, ship to ship and ship to helicopter communications systems will allow safe and efficient communications and RAS operations. The communications equipment and systems provided are to take into account the design of the ship and intended method of operation. Redundancy is also to be considered.

(m) Provide evidence that each system is designed to minimise the risks associated with handling the particular cargo (e.g. static electricity with aviation fuel).

(n) Address the disabling of automatic control, protection and safety functions for machinery and engineering systems where these are considered essential during replenishment at sea activities. The arrangements are to be consistent with the requirements of Vol 2, Pt 1, Ch 2,4.8.4.

Where applied standards are not in the public domain, e.g. ATP 16(latest version) covering NATO Replenishment at Sea, a copy is to be included with the engineering and safety justification.

5.1.6 **Fluid transfer plans and particulars**. For the receiving ship, plans ~~Plans~~ in diagrammatic form showing filling arrangements from the filling connection to filling trunks (where installed) and subsequently to each storage tank. The plans are to include a statement of the minimum flash point (closed cup test) together with the required and the maximum transfer/filling rates. For the supplying ship, plans in diagrammatic form showing pumping and piping arrangements from storage tanks to the ship's discharge connection. *See also* 9.1.10.

5.1.10 **Testing and trials procedures**. A schedule of testing and trials to demonstrate that systems are capable of operating as described in the design statement. The testing and trials procedures are to include details of through life load testing which includes the periodicity of load testing for different items of equipment.

5.1.11 Where an evaluation of an engineering and safety justification is required for the propulsion and steering arrangements (*see* 7.2.2), the following information is to be submitted:

(a) A Failure Modes and Effects Analysis (FMEA), *see* Vol 2, Pt 1, Ch 2,17.

(b) Design standards and any assumptions made.

(c) Limiting operating parameters for ship and machinery installation.

(d) A statement and evidence in respect of the reliability of any non-duplicated components.

■ *Section 6*
Ship and arrangement requirements

6.1 Location of RAS stations and equipment

6.1.1 Designated RAS stations are to be provided for RAS operations. RAS stations are to be positioned on the Supplying Ship to maximise compatibility with Receiving Ships and such that, as far as possible, the effects of hull interaction between the Supplying and Receiving Ships are minimised. For some types of naval ships, a reception point for the replenishment of ammunition may be required on the fo'c'sle. The number, type and location of ~~those~~ the RAS stations ~~is~~ are to be agreed between the Designer and Owner/Operator~~. As~~ but as a guide, for NS1 and NS2 type ships, it is usual practice to have up to six abeam RAS stations (three on the port side ~~port~~ and three on the starboard side) located symmetrically about the ship's centre line. *See also* 4.2.1. ~~with one of these located on the fo'c'sle to enable replenishment of ammunition direct to the fo'c'sle.~~

6.1.3 Where possible on receiving ships, an abeam RAS station is to be located amidships to maximise crew protection during RAS operations during heavy weather conditions.

6.1.7 Clear and safe access to all rigging securing points is to be provided. Arrangements are to be provided to ensure that access to those securing points high on the superstructure can be reached safely and speedily. As far as practicable, the ~~The~~ arrangements are to be such that there is no requirement for personnel to climb masts to gain access to RAS high points.

CORRIGENDUM

6.1.8 The access arrangements to all securing points are not to expose crew to dangerous electromagnetic hazards, *see* Vol 2, Pt 1, ~~Ch 2,4.18~~ Ch 2,4.19.

Effective date 1 January 2007

6.5 Location and layout of stores

6.5.2 The routes from RAS stations to stores are to be designed to simplify loading and movement of stores, equipment and provisions during RAS operations. The arrangements are to recognise minimising tripping hazards and the need for two people to pass without restriction.

6.6 Ship's structure

6.6.1 Depending on the intended functional requirements of the ship, each ~~Each~~ RAS station that is designed to receive and/or supply solids during RAS operations is to have a designated dump area in the case of receiving ships and/or a dispatch area for supplying ships. The dump area is to be suitably stiffened and designed to withstand the impact loads that may arise whilst landing stores and equipment on board during RAS operations.

6.6.3 The location of the dump area and/or dispatch area within the RAS station is to be agreed between the Designer and Owner/Operator and is to centre on the high point where applicable.

■ *Section 7*
Ship operating system requirements

7.2 Machinery redundancy

7.2.2 Where ships are fitted with single screw propulsion and single rudder arrangements or having the additional **L** character assigned to a machinery redundancy notation (*see* Pt 5, Ch 5), an evaluation of a detailed engineering and safety justification will be required, *see* 5.1.11. The evaluation process is to include the appraisal of a Failure Modes and Effects Analysis (FMEA) to verify that sufficient levels of redundancy and monitoring are incorporated in the propulsion and steering systems to support effective manoeuvring control of the ship during RAS operations.

7.4 Communications, signals and navigational aids

7.4.2 As a minimum, means of effective ship internal communications are to be provided in accordance with Table 7.7.1. In addition, means of communications are to be provided for all those personnel involved with operation of equipment or movement of stores during RAS operations. For example, communications should be provided from the RAS station to:

(a) The operators of fuel system valves, who need to be advised promptly of the completion of RAS operations so that the fuel system may be re-configured for normal running (unless valve operation is by remote control from the Master Filling Control Station).

(b) Those responsible for arranging for the supply and stowing the solid cargo who need to be appraised (quantity and type) of the stores en-route and the completion of RAS operations.

(c) The replenishment control office where provided.

The communication equipment and systems provided are to take into account the design of the ship (e.g. the Master Filling Control Station may be located on the Bridge) and the intended method of operating the ship during RAS operations.

(*Part only shown*)

Table 7.7.1 Internal communications

NOTE
Each RAS station on the ship is to be capable of communication with the conning/command position, RAS equipment control station and the master filling control station and the replenishment control office where provided.

CORRIGENDUM

7.5 RAS operations

7.5.3 RAS systems are to be designed and installed such that they do not degrade from defined criteria (for equipment and the ship) stemming from susceptibility to magnetic interference sources that may include military activities. Systems are to comply with the technical requirements of IEC ~~Publication~~ 60533: *Electrical Installations in Ships, electromagnetic Compatibility*. Emission limits and immunity requirements are to be agreed by the Naval Authority where those specified in IEC 60533 are not appropriate for the ship type.

Effective date 1 January 2007

■ *Section 8*
RAS station requirements

8.1 General

8.1.9 Oil spill containment arrangements are to be provided at each RAS station at which fuel and/or oil is taken on board or supplied for both Supplying and Receiving Ships. These arrangements are to cater for small spills that may occur during hose handling and connection operations. Small quantities of fuel or oil that may be spilt are to be contained and be capable of being discharged to a safe location and not overboard. Attention is drawn to the requirements of the *International Convention for the Prevention of Pollution of the Sea by Oil, 1973/1978* and to any applicable Naval/National Regulations relating to the prevention of oil spills at sea and in harbour.

8.3 Emergency equipment

8.3.1 A RAS emergency equipment locker is to be provided and located near each RAS station. The locker is to contain all the emergency equipment and tools required to conduct emergency breakaway procedures for each RAS operation and equipment configuration. Emergency tools are to be provided in a man-portable container that can be placed to be 'ready to hand' during RAS operations. There are to be sufficient emergency tools or containers for at least two simultaneous RAS operations.

Section 9

Transfer of liquids

9.1 General

9.1.4 The design and arrangements of liquid transfer systems is to permit clearing/drainage ~~blowing through/~~effective drainage of transfer hoses after RAS operations have been completed.

9.1.5 The arrangements for abeam transfer of oil fuel, lubricating oils, aviation fuel and fresh water are to be such that in the event of a single failure in a transfer ~~filling~~ system, this does not prevent transfer ~~replenishment~~ of these liquids, e.g. more than one RAS connection on each side of the ship and the ability to fill any tank from each RAS station from designated connections is to be provided.

CORRIGENDUM

9.1.12 For requirements relating to electromagnetic hazards, *see* Vol 2, Pt 1, ~~Ch 2,4.18~~ Ch 2,4.19.

Effective date 1 January 2007

9.2 Filling and supply connections and arrangements

9.2.1 Filling and supply connections for liquid RAS operations are to be sited within the boundary of the RAS station. Oil fuel system risers are to terminate in the vicinity of the RAS dump area and are not to present a tripping hazard or impede the use of stores handling machinery. Each filling and supply connection is to be provided with an accessible isolating valve located in close proximity to its associated ~~immediately under the deck with the valve controls led to a position above the weatherdeck sited near the filling~~ connection. ~~[Positioning the valve under the deck is to provide a clear area at the RAS station to minimise tripping hazards and radar reflective surfaces].~~ *See also* 9.2.14.

9.2.2 As far as practicable, separate filling and supply connections are to be provided for each type of fluid that may be ~~taken on board~~ transferred. To reduce the risk of inadvertent incorrect hose connection, the filling and supply connections are to be of different types and separated as far as possible from each other and distinct for each type of liquid to be transferred.

9.2.4 Each filling and supply connection is to be provided with a permanently attached notice identifying the fluid storage system(s) connected to the filling and supply connection(s).

9.2.5 Filling and supply connections and associated isolating valves are to be made from ductile materials. Where ships are required to operate in cold weather environments, materials of toughness greater than grade E are to be used.

9.2.6 Filling and supply connections are to be designed to allow an emergency breakaway to take place safely, speedily and with a minimum effort from the crew.

9.2.7 Filling and supply arrangements for flammable/hazardous liquids are to be designed to minimise the risk of static electricity build-up. The piping arrangements within storage tanks are to have outlet ends configured to reduce turbulence and foaming of the fuel. *See* Vol 2, Pt 10, Ch 1,1.12 for requirements for control of static electricity.

9.2.8 The control of filling and supply operations for each system that can be used ~~replenished~~ during RAS operations is to be capable of being carried out from a designated Master Filling/Supply Control Station. Designated Master Filling/Supply Control Stations are to be provided with:

(a) Effective communication equipment that permits communication with locations identified in the engineering and safety justification.

(b) Indication of tank high level and overflow alarms.

(c) Tank level/content indication.

(d) A clear visual means of ascertaining the valve configuration of each filling/supply system.

9.2.11 Lubricating oil and fresh water transfer/filling arrangements are to be provided with a bulkhead filling connection positioned not less than 300 mm above the weatherdeck to minimise the risk of seawater ingress into the system.

9.2.13 Filling and supply connection arrangements are to be designed as far as possible to reduce the incidence of, or opportunity for dissimilar metal corrosion.

9.1.14 Where ship design and arrangements permit, a dedicated compartment may be provided in close proximity to the RAS station which can be accessed from both port and starboard sides in which the commodity connection points, isolation valves and hoses are housed. This reduces the likelihood of dissimilar metal corrosion, negates the requirement for below deck isolating valves, flush deck fittings and reduces the upper deck clutter (radar cross section) associated with stowing the hoses on the weather deck.

Section 10

Transfer of solids

10.1 General

10.1.2 For ships intended for receiving solid supplies, the ~~The~~ design of arrangements is to provide for rapid removal of cargo from the RAS station once received on board. The arrangements and equipment are to recognise the reception of large and/or heavy items of cargo and the number of crew required. A typical maximum transfer rate is 25 pallets (each pallet up to 2 tonnes) every hour in fair weather ~~one pallet (1 m^3) every sixty seconds in good~~ conditions. The design transfer rate is to be agreed between the Owner/Operator, Designer and LR.

10.1.5 For ships intended for supplying solid supplies, the design and arrangements is to provide for the safe and orderly transfer of solids to the RAS station consistent with safe working practices.

■ *Section 11*
Transfer of personnel

11.1 General

11.1.2 Unless specifically approved by the Navy, ~~In general~~ only manually powered equipment is to be installed for the transfer of personnel.

~~*11.1.4*~~ *11.1.3* The design of arrangements for personnel is to provide sufficient space for the large numbers of crew normally required to operate the transfer equipment, typically twenty five personnel to tension the rig on a receiving ship.

~~*11.1.3*~~ *11.1.4* The mechanical devices used in the tensioning of any rigging and the transfer chair together with all transfer gear are to be of a proven safe design suitable for the purpose. The arrangements are to be such that when conducting a light jackstay transfer from a sliding pad-eye, the height of the pad-eye can be raised/lowered to facilitate the connecting/disconnecting process, but is to remain at a suitable fixed height during the actual transfer.

■ *Section 13*
Testing and trials

13.1 General

13.1.2 Testing and marking of equipment is to be in accordance with Chapter 9 of LR's *Code for Lifting Appliances in a Marine Environment* as applicable. Note that enhanced design factors of safety may be required with reference to handling and transfer of explosives and personnel, *see* 1.3.1(b) and (c), and load testing will be required consistent with the system design requirements.

■ *Section 14*
Survey through life

14.1 General

14.1.2 Survey and testing of systems and equipment are to be in accordance with Chapter 9 of LR's *Code for Lifting Appliances in a Marine Environment* as applicable. Note that enhanced design factors of safety may be required with reference to handling and transfer of explosives and personnel, *see* 1.3.1(b) and (c), and load testing will be required consistent with the system design requirements.

14.1.3 The periodicity of load testing is to be in accordance with the testing and trials procedures required by 5.1.10. Load testing is to be carried out under the supervision of a competent person.

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